Yacovone, Krista

From:	DiPippo, Gary <Gary.DiPippo@Cornerstoneeg.com>
Sent:	Tuesday, August 06, 2013 5:00 PM
To:	Gorin, Jonathan
Cc:	John M. Hoffman; Carrie McGowan; Scott MacMillin (SMacMillin@brwncald.com)
Subject:	LCP Site, FS Report Redline
Attachments:	LCP_Final_FS_rpt_redline.pdf; Table ES-1 Combined Site Remedies.pdf; Table ES-2 - Detailed Alt Eval.pdf; Table ES-3 - Comparative Analysis.pdf; Table 2-4 COPCs.pdf; Table 4-2 PRGs.pdf; FIGURE 2-5 SOIL SUMMARY.PDF; Table 4-1_ARARs.doc

Good afternoon Jon.

Per the discussions during our conference call on July 18, 2013, attached is a redline version of the Feasibility Study Report for the LCP Site.

The revisions reflect the response to comments sent to the USEPA on May 7, 2013, as well as the subsequent discussion during the July 18 conference call.

Along with the text we have attached the tables from the Executive Summary, the COPC and PRG tables, and the figure with the depth intervals of visible mercury added. Other tables, such as the detailed cost estimates, contain similar information to what is summarized in the Executive summary tables, and most of the figures are unchanged. However, if there is anything else that you would like to review in advance of the final submittal, please let us know.

In your electronic mail message of July 18, 2013, you indicated that EPA would be revising the ARAR table. We are uncertain as to whether you intended to send a markup or needed the active Word® file. In the event it helps, we have attached the Word® file for your use. We would appreciate it, if you do use the Word® file, if you would return it as a redline so that Ashland's review of the changes will be facilitated.

Please let us know if you have questions or comments, or need anything else.

Thank you.

Gary J. DiPippo, P.E.
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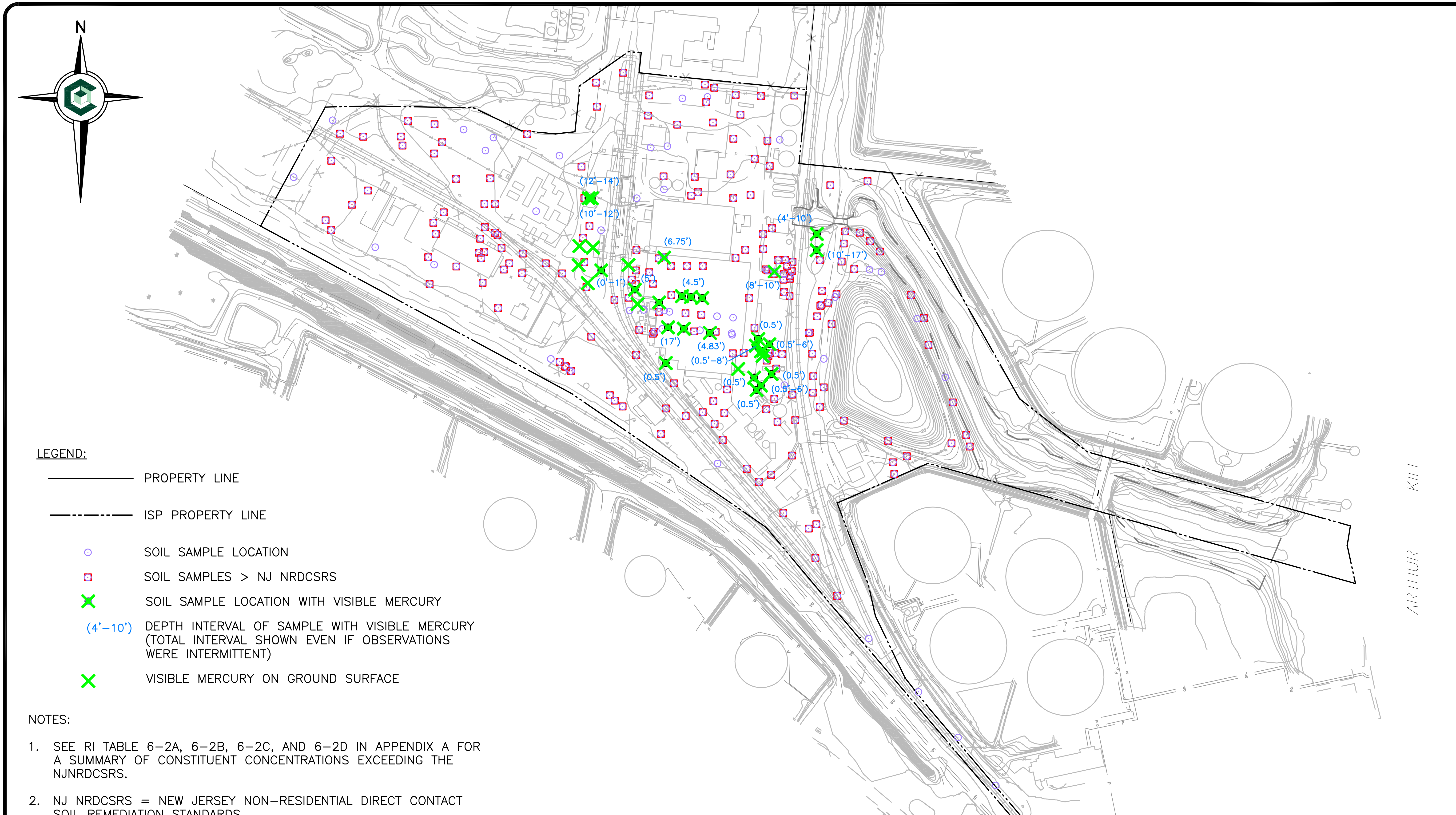

LEGEND:

PROPERTY LINE

ISP PROPERTY LINE

SOIL SAMPLE LOCATION

SOIL SAMPLES > NJ NRDCSRS

SOIL SAMPLE LOCATION WITH VISIBLE MERCURY

(4'–10') DEPTH INTERVAL OF SAMPLE WITH VISIBLE MERCURY (TOTAL INTERVAL SHOWN EVEN IF OBSERVATIONS WERE INTERMITTENT)

VISIBLE MERCURY ON GROUND SURFACE

NOTES:

1. SEE RI TABLE 6–2A, 6–2B, 6–2C, AND 6–2D IN APPENDIX A FOR A SUMMARY OF CONSTITUENT CONCENTRATIONS EXCEEDING THE NJNRDCSRS.

2. NJ NRDCSRS = NEW JERSEY NON–RESIDENTIAL DIRECT CONTACT SOIL REMEDIATION STANDARDS.

3. SEE RI TABLE 6–3 IN APPENDIX A FOR A SUMMARY OF SOIL SAMPLE VISUAL MERCURY OBSERVATIONS.

0 200 400

SCALE IN FEET

CORNERSTONE Engineering Group, LLC

FEASIBILITY STUDY – LCP CHEMICALS, INC. SUPERFUND SITE, LINDEN, NEW JERSEY

SUMMARY OF SOIL SAMPLING RESULTS

FIGURE NO. **2-5**

PROJECT NO. 090432

File: X:\PROJECTS\ISP\090432 – LCP FEASIBILITY STUDY\Project Drawings\Draft FS\Section 2_NRDCSRS and vis hg – REVISED.dwg Layout: Layout1 User: sam.waizenegger Aug 05, 2013 – 10:28am

FINAL FEASIBILITY STUDY

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LCP CHEMICALS, INC. SUPERFUND SITE

LINDEN, NEW JERSEY

Prepared for
ISP Environmental Services Inc.
August 2012

Deleted: December

Deleted: 2011

Prepared by

CORNERSTONE
Engineering Group, LLC
90 Crystal Run Road, Suite 201
Middletown, New York 10941

Project 090432

Final Feasibility Study
LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

Deleted: **Draft Feasibility Study**
LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

The material and data in this report were prepared under the supervision and direction of the undersigned.

Cornerstone Engineering Group, LLC

____
Gary J. DiPippo, Professional Engineer
NJ License No. 24GE02646100
Manager, Hydrogeology and Remediation

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EXECUTIVE SUMMARY

This report presents the results of a Feasibility Study (FS) for the LCP Chemicals, Inc Superfund Site (LCP site) in Linden, New Jersey prepared on behalf of ISP Environmental Services Inc. The LCP Chemicals, Inc. Superfund Site is designated as a National Priorities List (NPL) site, identified by the US Environmental Protection Agency (USEPA) as site No. NJD079303020 and is subject to Administrative Order No. II CERCLA-02-99-2015. A Remedial Investigation (RI) and associated human health (HHRA) and ecological risk (BERA) assessments were performed by Brown and Caldwell (RI) and Geosyntec Consultants (HHRA, BERA).

This FS report uses the RI and risk assessment findings to develop remedial action objectives (RAOs) for the Site, evaluate remedial technologies and alternatives, and complete detailed and comparative evaluations of the remedial alternatives to meet the RAOs. The FS uses a sequential process for selecting alternatives for detailed and comparative analyses. Application of this FS process has resulted in the alternatives presented in Table ES-1, which use containment, containment with a treatment component, and containment with an off-site disposal component as alternatives to meet the RAOs. The detailed evaluation of the alternatives presented in Table ES-1, against the threshold and balancing criteria described in the *National Contingency Plan* and in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* is summarized in Table ES-2. Table ES-3 presents a summary of the comparative analysis of the alternatives. In addition, an overall ranking is presented on Table ES-3 for each alternative based on its ability to meet the evaluation criteria, and for ease of comparison of the alternatives. Additional summary information on the Site background, the FS process, and alternative development and evaluation follow.

Site Description Summary and History

The LCP Site is located in the Tremley Point section of the City of Linden, Union County, New Jersey, along the western shore of the Arthur Kill. The Site was formerly an industrial complex with chemical manufacturing operations. In 1942, the United States Justice Department seized American I.G. Chemical Corporation, the LCP Site property owner at the time, as a war asset, and maintained ownership until 1965. While under government control, the General Aniline & Film Corporation completed construction of a chlor-alkali (chlorine manufacturing) plant on the LCP Site in 1955. The mercury-cell, chlorine production (chlor-alkali) facility was operated at the Site from 1955 until manufacturing operations ceased in 1985, and included a mercury-cell chlorine process area, hydrogen gas processing plant, and sodium hypochlorite manufacturing area. After LCP ceased the chlor-alkali manufacturing operations in 1985, the facility was used as a terminal for products from other LCP locations. Various other tenants operated at the Site subsequent to the end of the chlor-alkali manufacturing operations and included the following:

- Caleb Brett leased a portion of the property for the storage of various petroleum materials from 1988 to 1995.
- Microcell Technologies leased building 231 for the operation of a pilot plant which produced small glass spheres from 1987 to 2000.
- Active Water Jet Inc., a pipe and tank cleaning company, operated on site from about the early 1990s until 2000.

Hanlin Group, Inc., d.b.a. LCP, filed a petition under Chapter 11 of the bankruptcy code in 1991 and liquidated all of its assets before April 1994. The property was abandoned by Hanlin Group pursuant to an order of the Bankruptcy court and ownership reverted from the bankruptcy estate. Title to the property is currently listed as LCP Chemicals New Jersey, a d.b.a. name for Hanlin.

The Hanlin Group is now a defunct corporate entity. With the departure of the last tenant, Active Water Jet Inc., in 2000 the Site was abandoned and has remained so ever since. There are no active operations or personnel at the Site. Most of the buildings, in particular the mercury cell buildings, are in an advanced state of disrepair and are unsafe to enter.

The area surrounding the LCP Site was historically developed for heavy industrial use, much of which is currently inactive and/or decommissioned. Primary current, active land use in the area is bulk storage and transport of petroleum products and aggregates. Tidal wetlands are known to have existed historically in the area. The placement of anthropogenic fill to raise the grade for industrial development is known to have occurred starting in the 1880s along the margins of the Arthur Kill, and finishing circa 1955. The anthropogenic fill found on the LCP Site and vicinity has been mapped as "Historic Fill" by the NJDEP.

Deleted: meets the definition of "Historic Fill" contained in the New Jersey "Technical Requirements for Site Remediation" (N.J.A.C. 7:26E-1.8) and

Site Characterization Summary

The relevant characteristics of the Site related to the development of remedial alternatives are summarized as follows:

- The LCP Site, South Branch Creek, and the Northern Off-Site Ditch are impacted with multiple contaminants (e.g., mercury), due to the historic LCP site operations and due to the presence of anthropogenic fill and the heavily industrialized nature of the area around the Site.
- Site soils contain various constituents with concentrations above the NJ Non-Residential Direct Contact Soil Remediation Standards (NRDCSRS) throughout the Site. The primary soil contaminant is mercury from the LCP operations.
- The forms of mercury found in Site soils are insoluble or of low solubility (elemental mercury and metacinnabar) and, therefore, are relatively immobile, and as a result mercury contamination in groundwater is limited.
- Because of the properties of elemental mercury (e.g., bioaccumulative, persistent), soils containing visible, elemental mercury are the focus of the preference under the Superfund Amendments and Reauthorization Act (SARA) for remedial actions that employ treatment technologies, and are considered in this FS to be principal threat waste. The estimated quantity of soil at the Site containing visible elemental mercury (principal threat waste) is 23,600 cubic yards.
- The subsurface at the site beneath the former manufacturing buildings, in the area of visible elemental mercury, contains numerous subsurface structures such as piles and pile caps from foundations. As such a second estimate of the quantity of soil containing visible elemental mercury was calculated for a maximum depth of six feet, as a means to address the potential complications from subsurface obstructions. This quantity is 18,100 cubic yards.
- Shallow groundwater within the overburden contains dissolved concentrations of various constituents (VOCs, SVOCs and metals) above Class IIA groundwater quality criteria, though groundwater contamination shows minimal migration horizontally and is not moving off Site to any significant extent.
- Bedrock groundwater underlying the western portion of the Site contains concentrations of VOCs, SVOCs and metals attributable to the adjacent LPH site. The currently operating groundwater extraction and treatment system on the LPH site is capturing groundwater within this area. Bedrock groundwater closest to the natural discharge point represented by the Arthur Kill exceeds human health

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criteria for arsenic and manganese, but does not exceed any of the aquatic saline surface water quality standards.

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- Sediment and low marsh soils within South Branch Creek and sediment within the Northern Off-Site Ditch are contaminated with mercury and other constituents above comparative criteria, especially in the near-facility areas. The most likely source of these elevated concentrations is attributable to historic overland flow from impacted areas of the Site and is not considered an ongoing source.
- Biological specimens (i.e., fish and crabs) collected in South Branch Creek contain elevated concentrations of mercury and other constituents compared with those collected in nearby areas. Several constituents in South Branch Creek sediment have the potential to result in adverse ecological effect to benthic macroinvertebrates.
- Human exposures to site media are currently limited since the site is unoccupied and fenced. The human health risk assessment indicated that areas of visible elemental mercury are assumed to present an unacceptable risk for future commercial/industrial, site-specific, and construction/utility workers based on potential direct contact and vapor pathways under current, unremediated conditions.

Remedial Action Objectives

The remedial action objectives established for the FS are as follows:

- Prevent or minimize potential current and future human and wildlife exposures - including ingestion and dermal contact with soils and groundwater - that present a significant risk.
- Minimize migration of contaminated groundwater, and to the extent practicable, remediate groundwater to applicable standards.
- Remediate sediment in South Branch Creek, Northern Off-Site Ditch, and associated wetlands to levels protective of biota.
- Prevent or minimize human exposure to contaminated building materials and physical hazards that may result in potentially unacceptable risk.

Feasibility Study Process

The FS was conducted by the following process for the sequential development of remedial alternatives:

- Identification of applicable general response actions (i.e., broad categories of remedial action);
- Identification and screening of technologies within retained general response actions;
- Development of alternatives from the technologies retained following screening for each contaminated medium on Site;
- Screening of alternatives to narrow the field to the most appropriate options per medium; and
- Combining media-specific alternatives into a representative number of combined site remedies. Detailed and comparative analyses of these combined site remedies was then .performed

General Response Actions

General response actions are broad categories of remedial response that may meet the remedial action objectives and provide technologies applicable to site-specific characteristics. The general response actions that were reviewed for their applicability to the LCP Site are as follows:

- No action
- Limited Action / Institutional Controls
- Containment
- In-situ Treatment
- Ex-situ Treatment
- Collection / Discharge
- Removal
- Disposal

Technology Identification and Screening

A variety of technologies were identified as being potentially applicable to the LCP site and were screened against the criteria of effectiveness, implementability, and cost. This screening process eliminated inapplicable or inappropriate technologies and resulted in the following technologies being retained for the development of remedial alternatives:

Media	Retained Technologies
All Media	Institutional Controls
	Capping
	Treatment Cap
	Vertical Cutoff Walls
Soil/Sediments	Excavation/Dredging
	Vacuuming
	On-Site or Off-Site Landfill Disposal
	Soil Washing (with potential addition of chemical leaching)
	Off-Site Thermal Retort
	Solidification/Stabilization
	Stabilization
Groundwater	Shallow Groundwater Collection Trench
	Ex situ Treatment (existing LPH site treatment plant) and Discharge to Surface Water
	Discharge to POTW
Building Debris	Off-Site Thermal Retort
	Stabilization
	Debris Washing / Vacuuming

Alternative Development and Screening

From the screened list of technologies, the following media-specific alternatives were developed:

Media	Alternative	Description of Alternative
Soil	Alternative No. 1S	No action
	Alternative No. 2S	Cap and Institutional Controls (IC)
	Alternative No. 3S	Selective Mercury Removal, Capping, Barrier Wall and IC
	Alternative No. 4S-1	Partial Depth Selective Excavation, Capping, Off-Site Disposal and IC
	Alternative No. 4S-2	Full Depth Selective Excavation, Capping, Off-Site Disposal and IC
	Alternative No. 5S	Cap, Barrier Wall and IC
	Alternative No. 6S	Treatment Cap, Barrier Wall and IC

Media	Alternative	Description of Alternative
Soil	Alternative No. 7S	Selective Treatment by Solidification / Stabilization, Cap and IC
	Alternative No. 8S-1	Partial Depth Selective Treatment by Stabilization, Cap and IC
	Alternative No. 8S-2	Full Depth Selective Treatment by Stabilization, Cap and IC
	Alternative No. 9S-1	Partial Depth Selective Treatment by Soil Washing, Cap and IC
	Alternative No. 9S-2	Full Depth Selective Treatment by Soil Washing, Cap and IC
	Alternative No. 10S	Excavation and Off-Site Disposal
Groundwater	Alternative No. 1GW	No action
	Alternative No. 2GW	Cap and Barrier Wall, Shallow Groundwater Collection and Treatment, Long-Term Monitoring of Deep Groundwater and IC
	Alternative No. 3GW	Shallow Groundwater Collection and Treatment, Long-Term Monitoring of Deep Groundwater and IC
Sediments	Alternative No. 1SD	No action
	Alternative No. 2SD	Erosion Controls and New Benthic Layer, and Restore/Mitigate Disturbed Wetlands
	Alternative No. 3SD	Selective Excavation of Sediments, Place On-Site, and Restore/Mitigate Disturbed Wetlands
	Alternative No. 4SD	Excavate Sediments, Place On-Site, and Restore/Mitigate Disturbed Wetlands
	Alternative No. 5SD	Excavate Sediments, Off-Site Disposal and Restore/Mitigate Disturbed Wetlands
Building Debris	Alternative No. 1B	No action
	Alternative No. 2B	Demolish, Recycle Steel, Place Other Materials On-Site
	Alternative No. 3B	Demolish, Recycle Steel, Dispose of Other Materials Off-Site
	Alternative No. 4B	Demolish, Recycle Steel, Placement of Other Materials Partially On-site and Off-Site Disposal of Remaining Debris

These alternatives were screened against the criteria of effectiveness, implementability and cost. Based on the results of the screening process, the following alternatives were retained because in general they are effective at meeting the remedial action objectives, control potential exposure, are protective of human health and the environment, provide either containment or treatment, are implementable, and are not redundant with another alternative of lesser cost:

Media	Alternative	Description of Alternative
Soil	Alternative No. 1S	No action
	Alternative No. 2S	Cap and Institutional Controls (IC)
	Alternative No. 4S-1	Partial Depth Selective Excavation, Capping, Off-Site Disposal and IC
	Alternative No. 4S-2	Full Depth Selective Excavation, Capping, Off-Site Disposal and IC
	Alternative No. 6S	Treatment Cap, Barrier Wall and IC
	Alternative No. 8S-1	Partial Depth Selective Treatment by Stabilization, Cap and IC
	Alternative No. 8S-2	Full Depth Selective Treatment by Stabilization, Cap and IC
Groundwater	Alternative No. 1GW	No action
	Alternative No. 2GW	Cap and Barrier Wall, Shallow Groundwater Collection and Treatment, Long-Term Monitoring of Deep Groundwater and Institutional Control
	Alternative No. 3GW	Shallow Groundwater Collection and Treatment, Long-Term Monitoring of Deep Groundwater and Institutional Controls
Sediments	Alternative No. 1SD	No action
	Alternative No. 3SD	Selective Excavation of Sediments, Place On Site, and Restore/Mitigate Disturbed Wetlands
	Alternative No. 4SD	Excavate Sediments, Place On Site, and Restore/Mitigate Disturbed Wetlands
Building Debris	Alternative No. 1B	No action
	Alternative No. 2B	Demolish, Recycle Steel, Place Other Materials On Site
	Alternative No. 4B	Demolish, Recycle Steel, Placement of Other Materials Partially On Site and Off-Site Disposal of Remaining Debris

Development of Site Remedies

To allow for a manageable detailed evaluation process, the medium-specific alternatives described above were examined in a logical manner to produce a representative number of combined site remedies that could be evaluated in accordance with the regulations. The retained media-specific alternatives were combined into representative site-wide remedies, as follows:

Site Remedy No. 1: No action (baseline for comparison of other alternatives)

Site Remedy No. 2: Partial Containment (Treatment Cap) – this alternative focuses on capping as the primary soils remediation component and is combined with shallow groundwater collection, sediments remediation, and building demolition.

Site Remedy No. 3: Full Containment (Treatment Cap and Barrier Wall) – this alternative represents the containment-based option for the site soils and groundwater including the barrier wall component for lateral control of potential contaminant migration along with sediments remediation and building demolition.

Site Remedy No. 4a: Full Containment and Partial Depth Selective Stabilization – this alternative adds a visible elemental mercury treatment component (stabilization) to the containment-based remedy, to a maximum depth of six feet, along with shallow groundwater collection, sediments remediation, and building demolition

Site Remedy No. 4b: Full Containment and Full Depth Selective Stabilization – this alternative is the same as No. 4a, but is not depth limited.

Site Remedy No. 5a: Full Containment and Partial Depth Selective Excavation and Off-Site Disposal – this alternative focuses on off-site disposal of visible elemental mercury as a remedial component, with the maximum depth of excavation limited to six feet, along with shallow groundwater collection, sediments remediation, and building demolition

Site Remedy No. 5b: Full Containment and Full Depth Selective Excavation and Off-Site Disposal – this alternative is the same as No. 5a, but is not depth limited.

Comparative Analysis of Site Remedies

The site remedies developed from the alternative screening process, as described above, were analyzed by comparison to seven of the nine evaluation criteria as described in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, which include:

- Overall protection of human health
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)
- Long-term effectiveness and permanence
- Reduction or toxicity, mobility, or volume
- Short-term effectiveness

- Implementability
- Cost

In addition to the above seven criteria, State acceptance is an evaluation criterion that was addressed through coordination between the USEPA and the NJDEP, and Community acceptance is an evaluation criterion that is addressed through the public participation process.

Table ES-2 presents a detailed evaluation of each site remedy against these seven criteria. Table ES-3 provides a summary of this evaluation and comparisons of the seven alternatives. A review of Tables ES-2 and ES-3 indicates the following when comparing the site remedies using the evaluation criteria:

- Protection of Human Health and the Environment
  - Each of the alternatives, with the exception of Site Remedy No. 1 – No Action, would meet the remedial action objectives and would generally be equally protective of human health and the environment through the elimination of the direct contact pathways (i.e., soil, groundwater, sediments) and through elimination of the inhalation pathway (i.e., mercury soil vapor).
  - Site Remedy No. 2 – Partial Containment (Treatment Cap) may be considered marginally less protective of human health and the environment than the other alternatives because it does not include a barrier wall, as the other combined site remedies do, which would further limit the potential for lateral migration of contamination within the site soils (e.g., vapor) and groundwater.
- Compliance with ARARs:
  - In general, with the exception of Site Remedy No. 1, the Site Remedies comply with ARARs.
  - Site Remedy Nos. 5a and 5b assume waste will be shipped to the Stablex facility in Canada; therefore, LDRs (Land Disposal Restrictions) for mercury would not be violated as these regulations only apply within the United States. The Stablex process of S/S treatment and landfill disposal would not be permissible at a US facility without a variance to LDR requirements.
- Long-Term Effectiveness:

Deleted: Community and State acceptance are two additional evaluation criteria that are addressed through the public participation process.

Deleted: <#>The only facility identified to accept visible elemental mercury impacted soil is the USEcology/Stablex facility in Canada. Even though Site Remedy Nos. 5a and 5b are considered protective with respect to the Site remediation, the off-Site disposal of soil containing visible elemental mercury outside of the United States raises questions about the larger scale protectiveness of these two alternatives. These Site Remedies represent the potential displacement and not necessarily the proper treatment and disposal of soils containing visible elemental mercury. The USEcology/Stablex facility uses S/S technology which as discussed in Section 6, is not a proven technology for the treatment of visible elemental mercury. In effect, it is possible, that if the S/S process (which is proprietary and therefore limited information is available) were to potentially increase mercury mobility or the mobility of other constituents, the protectiveness of off-Site disposal would not be improved by comparison to the soils remaining on Site (i.e., containment would provide the control in both cases). ¶

Deleted: , while not violating LDRs for mercury as LDR regulations only apply within the United States, would circumvent the intent of the LDR regulations (or the alternative treatment standards for contaminated soil) through the shipment of high subcategory mercury wastes and elemental mercury wastes out of the US (i.e.,

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- In general, with the exception of Site Remedy No. 1, the Site Remedies are effective in the long-term given proper maintenance of the soil cap and shallow groundwater collection systems. There is little difference between the various Site Remedies in terms of long-term effectiveness as they are all suitable to achieve the RAOs over the long term.
- Site Remedy Nos. 4a and 4b provide an additional component to eliminate the mercury vapor pathway through conversion of visible elemental mercury to mercuric sulfide, which is a potentially permanent conversion. Treatability/pilot studies would be required prior to remedy implementation to confirm applicability of stabilization to the site soils, to define operational parameters for the in-situ stabilization process, and to determine treatment efficiencies. Such treatability testing may also shed light on the long-term stability of the conversion. In addition, this conversion of elemental mercury to mercuric sulfide does not have any real measureable benefits in protectiveness
- Site Remedy Nos. 2 and 3 also provide for an additional component to eliminate the mercury vapor pathway through the implementation of a treatment cap over the area of observed visible elemental mercury. In terms of effectiveness, there is no discernible difference between Site Remedy Nos. 2, 3, 4a, and 4b in terms of eliminating the inhalation exposure pathway and limiting the potential accumulation of mercury vapor below the cap.
- Site Remedy Nos. 5a and 5b provide for the permanent transfer of a portion of the contaminated soil to an off-site disposal facility, and as such the result of this work is effective in the long-term for the site. Barring additional information to the contrary on the Stablex process and disposal facility operation, one can presume that the controls at that facility should be effective in the long term. Similar to Alternatives 4a and 4b, the removal of a portion of the contaminated soil does not have any real measureable benefits in protectiveness.

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- Reduction of Toxicity, Mobility, or Volume:
  - In general, with the exception of Site Remedy No. 1, the Site Remedies reduce the mobility of contaminants, principally through the containment components, not through treatment as is the intent of this evaluation criterion. Site Remedy No. 2 potentially reduces mobility marginally less than the other Site Remedies because it does not include a barrier wall

component, which further limits the potential for lateral migration of contaminants. However, this difference is not substantial.

- Site Remedy Nos. 2 and 3 provide for the treatment of mercury vapors below the cap through the implementation of a treatment cap over the area of identified visible elemental mercury; which results in a decrease in both mobility and volume of elemental mercury. However, the total mass of mercury present on the Site remains unchanged, only its form is altered.
- Site Remedy Nos. 4a and 4b provide for conversion of visible elemental mercury to mercuric sulfide through in-situ stabilization, resulting in a potential decrease in mobility (mercuric sulfide is insoluble, whereas elemental mercury is of finite but very low solubility), and a decrease in the volume of elemental mercury. However, after stabilization the same overall mass of mercury remains in the Site soils. The only difference is additional control of the vapor pathway. Without the containment component of these remedies both would continue to exhibit unacceptable, potential excess risk from contaminants associated with the site operations as well as those present as a result of the placement of anthropogenic fill.
- Site Remedy Nos. 5a and 5a provide for the removal of visible elemental mercury, resulting in a decrease in volume, mobility and toxicity of mercury in the Site soils.

Deleted: The only disposal option for this visible elemental mercury is outside of the United States. Also, even after removal of the portion of the contamination addressed by these alternatives, without the containment components of these remedies, the RAOs would not be met, ARARs would not be met, and potential incremental risks would remain above acceptable regulatory thresholds.

- Short-Term Effectiveness:
  - In general, Site Remedy Nos. 2 and 3 will be the quickest to implement, whereas Site Remedy Nos. 4a and 4b will require the longest implementation time period, due primarily to the time required to mix the soils during the in-situ stabilization process to achieve adequate contact between the sulfur and visible elemental mercury. In addition, Site Remedy Nos. 4a and 4b would require treatability studies, which would lengthen the remedy design process compared to the other remedies, although Site Remedy Nos. 5a and 5b may also require some pre-acceptance treatability testing as well.
  - In general, all Site Remedies will result in an increase in mercury vapor emissions over baseline conditions. Site Remedy Nos. 5a and 5b represent the largest increase in mercury vapor emissions during remedy implementation (101 to 197 pounds), and have the greatest potential for air emissions issues (permitting and/or actual performance). Site Remedy Nos. 4a and 4b represent the smallest increase in mercury vapor emissions

during remedy implementation (approximately 0.5 to 0.8 pounds) because of the more widespread use of a sulfur compound. Site Remedy Nos. 2 and 3 have incremental mercury vapor emissions in the range of 7.7 pounds.

- Implementability:
  - In general, all Site Remedies are implementable with conventional materials and equipment.
  - Site Remedy Nos. 4a and 4b would require specialized equipment for soil mixing.
  - Site Remedy Nos. 4b and 5b are inherently more difficult to implement than Site Remedy Nos. 4a and 5a due to greater depth of remedy implementation and the associated subsurface obstructions.
  - Site Remedy Nos. 5a and 5b, require transport and disposal of visible elemental mercury wastes outside the United States. The only facility identified to accept visible elemental mercury impacted soil is the USEcology/Stablex facility in Canada. USEcology/Stablex has indicated uncertainty regarding the ability to provide the requisite disposal capacity. If visible elemental mercury remains following treatment at the USEcology/Stablex facility, it is sent for retorting, and then under the Mercury Export Ban Act, would have to be returned to the Site. In addition, the off-Site disposal of soil containing visible elemental mercury outside of the United States raises questions about the larger scale protectiveness of these two alternatives. These Site Remedies represent the potential displacement and not necessarily the proper treatment and disposal of soils containing visible elemental mercury. The USEcology/Stablex facility uses S/S technology which as discussed in Section 6, is not a proven technology for the treatment of visible elemental mercury. In effect, it is possible, that if the S/S process (which is proprietary and therefore limited information is available) were to potentially increase mercury mobility or the mobility of other constituents, the protectiveness of off-Site disposal would not be improved by comparison to the soils remaining on Site (i.e., containment would provide the control in both cases). In addition, even after removal of the portion of the contamination addressed by these alternatives, without the containment components of these remedies, the RAOs would not be met,

ARARS would not be met, and potential incremental risks would remain above acceptable regulatory thresholds.

- Cost:
  - Site Remedy No. 2 is the least expensive remedy whereas Site Remedy No. 5b is the most expensive. As demonstrated in the comparisons above, Site Remedy No. 3 provides a level of protectiveness equal to the other alternatives and slightly better than alternative No. 2, but at a cost roughly 20-70% less than Site Remedy Nos. 4a and 4b, and roughly 350-450% less than Site Remedy Nos. 5a and 5b.
  -

Deleted: These alternatives are limited to a sole source for disposal capacity and this source (USEcology/Stablex) has indicated uncertainty regarding the ability to provide the requisite disposal capacity. In addition, uncertainty exists in the actual treatment process employed by Stablex (proprietary and therefore information is limited) and the potential for a significant amount of non-stabilized visible elemental mercury wastes to require retorting following the application of the Stablex process.

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1 INTRODUCTION

1.1 Purpose and Report Organization

This report presents the results of a Feasibility Study (FS) prepared on behalf of ISP Environmental Services Inc. for the LCP Chemicals, Inc. Superfund Site in Linden, New Jersey. The LCP Chemicals, Inc. Superfund Site is designated as a National Priorities List (NPL) site hereinafter referred to as "the Site" or the "LCP Site," and is identified by the US Environmental Protection Agency (USEPA) as site No. NJD079303020.

This FS has been prepared pursuant to Administrative Order No. II CERCLA-02-99-2015 (hereinafter referred to as the Order) issued by USEPA and as voluntarily executed by ISP Environmental Services Inc. (IES) on May 13, 1999. Specifically, this FS report has been prepared in satisfaction of the requirements of Section VII.25, Paragraph I, of the Order entitled *Task IX, Feasibility Study Report.* The stated purpose of the Order as it relates to the completion of the Remedial Investigation and Feasibility Study (RI/FS) is to:

> *(a)… conduct a remedial investigation ("RI") to determine the nature and extent of contamination and any threat to the public health, welfare, or the environment caused by the release or threatened release of hazardous substances, pollutants or contaminants at or from the Site; (b) to determine and evaluate alternatives, through the conduct of a feasibility study ("FS"), to remediate said release or threatened release of hazardous substances, pollutants, or contaminants….*

The RI and associated human health (HHRA) and ecological (BERA) risk assessments were performed by Brown and Caldwell and Geosyntec Consultants. As of the preparation of this FS report, the RI and BERA remain as drafts and IES continues to work with the USEPA to finalize these documents. The HHRA has been completed and has been issued as a final report (Geosyntec, May 2011). This FS report uses the RI and risk assessment findings to develop remedial action objectives (RAOs) for the Site, evaluate remedial technologies and alternatives, and complete detailed and comparative evaluations of the remedial alternatives to meet the RAOs. This report has been prepared in accordance with the USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988), along with other relevant regulations and guidance including the New Jersey *Technical Requirements for Site Remediation* (NJAC 7:26E), the

New Jersey *Administrative Requirements for the Remediation of Contaminated Sites* (NJAC 7:26C), and the New Jersey *Remediation Standards* (NJAC 7:26D).

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Coordination with the USEPA occurred throughout the process of preparing this final FS report, and to comply with the various provisions of the Order, as follows:

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- Submittal of an Identification of Candidate Technologies Technical Memorandum per Section VII.25, Paragraph D of the Order, which was approved by the USEPA on February 25, 2009.

- Meeting with USEPA in February 2009 and follow-up discussions to establish the RAOs for the Site.

- Meeting with USEPA in July 2009 to discuss the preliminary findings of alternatives screening.

- Submittal of a technical memorandum in August 2009 to provide the USEPA with further information regarding the preliminary findings of alternatives screening, focusing on treatment-based alternatives. The technical memorandum effectively screened out all treatment-based alternatives.

- Meeting with USEPA in January 2010 to discuss the August 2009 technical memorandum at which EPA indicated that in order for all treatment technologies to be screened out, treatability studies would need to be performed to demonstrate impracticability. In accordance with Section VII.25, Paragraph E of the Order, IES agreed to prepare a treatability work plan.

Deleted: Meeting with USEPA in January 2010 to discuss the August 2009 technical memorandum, and at which, in accordance with Section VII.25, Paragraph E of the Order, the USEPA made a determination that a treatability study work plan should be prepared.

- Submittal of a Treatability Study Statement of Work in accordance with Section VII.25, Paragraph E.1 of the Order, in February 2010, which was conditionally approved by the USEPA on April 2, 2010.

- Submittal of a Treatability Study Work Plan in accordance with Section VII.25, Paragraphs E.2 and E.3 of the Order, in May 2010. Based on the USEPA's review of this work plan and further discussions between the Agency and IES, along with input from Brookhaven National Laboratories, the USEPA on December 16, 2010, made a determination that treatability studies previously under consideration would be held in abeyance pending completion of the FS.

- Meeting with the USEPA in July 2011 to discuss the alternatives screening component of the FS and to obtain the USEPA's concurrence on alternatives to be subjected to detailed evaluation in the FS, per Section VII.25, Paragraph G of the Order. Subsequent electronic mail correspondence confirmed the candidate list of alternatives to be evaluated in this FS.

- Submittal of a draft FS in December 2011

- Meeting with USEPA and NJDEP in September 2012 to provide a summary of RI/FS results, present the retained proposed remedies for the site, and to address additional questions on the RI/FS results.

- Discussions with the USEPA to address the review of the alterantives by the National Remedy Review Board (NRRB), and incorporation of the NRRB comments into this final FS report.

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The results of the above coordination efforts have been incorporated into this final FS report.

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The remainder of this report is organized as follows:

- Section 1 describes the purpose and organization of this report along with background on the site history and status.
- Section 2 presents a summary of the findings of the remedial investigation, human health risk assessment, and baseline ecological risk assessment. In addition, Section 2 presents estimates of areas and volumes of media based on the findings of the RI.
- Section 3 presents the RAOs for the site and evaluates the applicability of various general response actions.
- Section 4 provides a discussion and tabulation of applicable or relevant and appropriate requirements (ARARs).
- Section 5 identifies and screens potentially applicable technologies, and has been updated from the technical memorandum approved by the USEPA in February 2009.
- Section 6 develops and screens potential remedial alternatives.
- Section 7 presents the detailed and comparative analyses of remedial alternatives remaining from the screening described in Section 6.

1.2 Site Description Summary and History

The LCP Site is located in the Tremley Point section of the City of Linden, Union County, New Jersey, along the western shore of the Arthur Kill. The Site location is illustrated on Figure 1-1. The Site is accessed from the Road to Grasselli, which is reached from Linden via South Wood Avenue and Tremley Point Road. The coordinates of the approximate center of the Site are Latitude 40.60832º and Longitude -74.21163º. The real property parcels on which the LCP Site is located include City of Linden Block No. 587, Lots No. 3.01, 3.02, and 3.03.

The Site was formerly an industrial complex with chemical manufacturing operations. In 1942, the United States Justice Department seized American I.G. Chemical Corporation, the LCP Site property owner at the time, as a war asset, and maintained ownership until 1965. While under government control, the General Aniline & Film Corporation completed construction of a chlor-alkali (chlorine manufacturing) plant on the LCP Site in 1955. The mercury-cell, chlorine production (chlor-alkali) facility was operated at the Site from 1955, until manufacturing operations ceased in 1985, and included a mercury-cell chlorine process area, hydrogen gas processing plant, and sodium hypochlorite manufacturing area. The Site was also used as a terminal for products from other facilities and various other industrial operations. In addition, a variety of tenants operated on the Site until it was closed in August 1994.

The area surrounding the LCP Site was historically developed for heavy industrial use, much of which is currently inactive and/or decommissioned. Primary current, active land use in the area is bulk storage and transport of petroleum products and aggregates. Tidal wetlands are known to have existed historically in the area. The placement of anthropogenic fill to raise the grade for industrial development is known to have occurred starting in the 1880s along the margins of the Arthur Kill, and finishing circa 1955. The anthropogenic fill found on the LCP Site and vicinity has been mapped as "Historic Fill" by the NJDEP.

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The Site Property has a long and complex history of ownership and industrial use, as described in detail in the RI. A number of property transactions occurred prior to Site development, and in 1955 the General Aniline & Film Corporation completed construction of the chlor-alkali plant on the Site. Various additional property transfers then occurred through 1967 while the Site was under the Ownership of General Aniline & Film Corporation (later known as GAF Corporation) that resulted in the current configuration of the Site of approximately 26 acres.

GAF Corporation sold the LCP Site which included the chlor-alkali facility to Linden Chlorine Products, Inc. of Edison, New Jersey in 1972. LCP Chemicals and Plastics, Inc. conveyed its property to LCP Chemicals-New Jersey, Inc. in 1979, and at some point, the company became known as LCP Chemicals, Inc., a division of the Hanlin Group, Inc.

As noted above, GAF began the chlorine operation at the LCP site in 1955. By 1956, the core of the buildings required for the chlorine productions were present. GAF had stopped operation of the chlor-alkali manufacturing facility in 1971, and subsequently Linden Chlorine Products, Inc. resumed operation of the plant after it purchased the property. Linden Chlorine Products, Inc. added site buildings in the early 1970s. Linden Chlorine Products, Inc. also acquired other chlor-alkali manufacturing facilities including sites in Syracuse, New York, Moundsville, West Virginia, and Brunswick, Georgia.

Portions of the LCP site were leased to other companies for the operation of other related manufacturing operations at the site. In 1957, part of the property to the west was leased to Union Carbide Corporation (UCC) to be used as a hydrogen plant utilizing the by-products of the chlorine plant and is known as the Linde Division hydrogen plant. UCC operated its plant through 1990. Kuehne Chemicals, Inc. leased the northern portion of the property in 1972 and opened a sodium hypochlorite manufacturing plant, which also distributed and sold chlorine.

LCP ceased the chlor-alkali manufacturing operations by 1985, and subsequently the facility was used by LCP as a terminal for products from other locations. Hanlin Group, Inc., d.b.a. LCP, filed a petition under Chapter 11 of the bankruptcy code in 1991 and liquidated all of its assets before April 1994. The property was abandoned by Hanlin Group pursuant to an order of the Bankruptcy court and ownership reverted from the bankruptcy estate. Title to the property is currently listed on the Linden tax roles as LCP Chemicals New Jersey, a d.b.a. name for Hanlin. Various other tenants operated at the Site subsequent to the end of the chlor-alkali manufacturing operations and included the following:

- Caleb Brett leased a portion of the property for the storage of various petroleum materials from 1988 to 1995.
- Microcell Technologies leased building 231 for the operation of a pilot plant which produced small glass spheres from 1987 to 2000.
- Active Water Jet Inc., a pipe and tank cleaning company, operated on site from about the early 1990s until 2000.

1.3 Site Status

The Hanlin Group is now a defunct corporate entity. With the departure of the last tenant, Active Water Jet Inc. in 2000, the Site was abandoned and has remained so ever since. There are no active operations or personnel at the Site. Some of the buildings, in particular the mercury cell buildings, are in an advanced state of disrepair and are unsafe to enter.

The Site was placed on the NPL in 1998. On May 13, 1999, the Order was entered into voluntarily by the USEPA and ISP Environmental Services Inc., and covers activities through the remedial investigation and feasibility study. ISP Environmental Services Inc. (IES) is currently the only cooperating party, among several potentially responsible parties, working on addressing the Site. ISP Environmental Services Inc., however, does not own the Site.

To date IES has completed or is continuing with the following activities at the Site, under the Order:

- Preparation of a Remedial Investigation (draft report submitted September 2008), a Human Health Risk Assessment (May 2011), and a Baseline Ecological Risk Assessment (draft report submitted September 2008), the findings of which provide the basis for this FS.

- IES currently performs routine, quarterly building observation and air monitoring at the Site to assess the condition of the Site buildings and the potential for mercury vapor emissions. The results of this air monitoring document that concentrations of mercury in air at the Site are within the limits established for this monitoring program, and there is no indication of the presence of mercury vapors in ambient air leaving the Site.

- IES has prepared this FS as the final task in fulfilling its obligations under the Order.

In addition to the above, IES proposed an interim remedial measure (IRM) for South Branch Creek, originally in 2007, and then proffered the concept again in 2011. To date, the USEPA has not opted to approve an IRM.

2 SITE CHARACTERIZATION

A multi-phase Remedial Investigation (RI) was completed for the LCP Site to characterize the physical setting, nature and extent of contamination, and fate and transport of contaminants; and to present baseline human health and ecological risk assessments. The work completed for the RI is reported in the document titled "Draft Remedial Investigation Report, LCP Chemicals, Inc. Superfund Site, Linden, New Jersey" (Brown and Caldwell, 2008). The RI was performed starting in 2001 (Phase I), continued in 2006-2007 (Phase II) and was most recently amended in 2011 (characterization of off-Site ditches).

The sections that follow summarize the results of the RI in the context of forming a basis for remedy evaluation, particularly as relates to the completion of this FS (e.g., defining the quantity of impacted soil or sediment that would be the subject of a remedy). The reader is referred to the RI for details beyond that provided in this summary. Consistent with the RI, the following summary discusses the overall physical setting of the Site, and the nature and extent of contamination within soils, soil gas, groundwater, and sediment. This is then followed by a summary of the contaminant fate and transport within these media and baseline risk assessments for human health and ecological risk.

2.1 Physical Setting

As previously noted in Section 1, the LCP Site is located in the Tremley Point section of the City of Linden, New Jersey, along the western shore of the Arthur Kill. The total Site area within the property boundaries is approximately 26 acres. The Site is bounded by current and former industrial operations with the primary current land use in the area being bulk storage and transport of petroleum products and aggregates.

The major features of the Site are illustrated on Figure 2-1, and may be summarized as follows:

- South Branch Creek, a man-made ditch, borders the eastern portion of the Site, and connects to the Arthur Kill, after passing through a culvert for a petroleum bridge crossing.

- To the west of South Branch Creek is a closed RCRA unit (closed per a RCRA permit in 1984), which contains brine sludge (K071) from the LCP operation.

- West of a railroad spur adjacent to the closed RCRA unit is the former LCP manufacturing area. The manufacturing area consists of various buildings and tanks, with the largest structures being the former cell buildings. Most buildings are in a state of disrepair and cannot be safely entered.

- The northern and westernmost portions of the property are occupied principally by abandoned buildings formerly associated with leases and processes operated by other companies, including the Linde hydrogen plant and the Kuehne Chemical sodium hypochlorite and chlorine packaging facility. In addition, a transformer and rectifier yard exists on the western portion of the site.

- To the southwest of the Site property boundary is a pair of parallel railroad tracks operated by Conrail and farther south are two parallel drainage channels, referred to as the Northern and Southern Off-Site Ditches, which were characterized as a part of the RI. The Northern Off-Site Ditch is believed to discharge to South Branch Creek near the bend in South Branch Creek located directly east of the culvert bridge crossing. The Southern Off-Site Ditch discharges to a channel leading to the Arthur Kill.

- The northern boundary of the site is currently owned by Linden Property Holdings LLC (LPH). This site was formerly used by GAF and was later owned by ISP/ESI. This site has NFAs for soil and groundwater from NJDEP and is currently vacant aside from groundwater extraction and treatment plant facilities and personnel.

The LCP Site has little topographic relief and ill-defined surface water drainage patterns. Remediation construction on the adjacent LPH Site to the north has obstructed drainage to the north due to the installation of a barrier wall. Drainage still exists overland to South Branch Creek and the Northern Ditch to the south, but with considerable ponding of runoff on the Site (i.e., there are no direct discharge points any longer). The surface water bodies adjacent to the site, South Branch Creek and the Arthur Kill are saline.

Wetlands exist on the Site along South Branch Creek as a band along the channel (see Figure 2-1). The NJDEP issued a Letter of Interpretation confirming these regulated wetland areas on February 16, 2007. Typically, the width of the wetlands is on the order of 50 to 100 feet. The total area of wetlands along South Branch Creek is approximately 2.3 acres (including open water) of which 1.9 acres are on the LCP property. Approximately 1.1 acres of wetland is upstream of the culvert crossing the Creek and the remaining portion is downstream of the culvert. The wetlands are classified as intermediate resource value and, therefore, have a 50-foot buffer.

The ecology of the Site is typical of industrialized areas adjacent to an intertidal marsh system. No rare, threatened, endangered or otherwise protected species of flora or fauna have been identified on the site. The habitat, including the wetlands, is considered degraded.

The various Site features are illustrated on Figure 2-1.

2.2 Geology and Hydrogeology

The geology of the LCP Site, in descending order, may be summarized as follows:

- Anthropogenic fill. A continuous layer of fill exists across the Site. The fill ranges in thickness from approximately 0.7 feet to as much as 17 feet with an average thickness of approximately nine feet. The fill is composed of a heterogeneous mix of soil, ash, wood, brick, and glass.

- Tidal Marsh Deposits. The tidal marsh deposits also underlie the entire LCP Site ranging in thickness from five to ten feet. Peat comprises the upper portion of the tidal marsh deposits (i.e., loose, soft, fibrous material) and grades to underlying organic silt and clay.

- Glacial Till. Underlying the tidal marsh deposits is a layer of fine-grained glacial till comprised primarily of silts and clays with minor amounts of sand and gravel. The glacial till ranges in thickness from 18.5 to 20.5 feet.

- Bedrock of the Passaic Formation. Beneath the glacial till is bedrock of the Passaic Formation. The upper portion of the bedrock is highly weathered residual soil composed of fine-grained silts and clays with shale fragments, similar to the overlying glacial till. The residual soil transitions to competent bedrock with depth.

Groundwater occurs in two hydrogeologic zones at the Site as follows:

- Within the fill and peat deposits as an overburden water bearing zone.

- Within the fractured bedrock of the Passaic Formation.

These two hydrogeologic zones are separated by an aquitard comprised of the organic silt and clay of the tidal marsh deposits and the glacial till. Each of these zones is discussed further below.

The overburden water bearing zone occurs as a mound within the fill and peat deposits, with discharge toward South Branch Creek and to the Northern Off-Site Ditch. Figure 2-2 is recreated from the RI to illustrate the configuration of the water table surface in the overburden water bearing zone. The hydraulic conductivity of the overburden zone is highly variable as would be expected in heterogeneous fill deposits. Hydraulic conductivity measurements in the overburden water-bearing zone ranged from 5.6×10^{-7} cm/sec to 4.6×10^{-1} cm/sec, with a geometric mean of 1.7×10^{-3} cm/sec. Given the variability of the hydraulic conductivity of the fill, the quantity of lateral flow within the overburden water-bearing zone can best be estimated through an assessment of infiltration of precipitation. In the northeastern United States, infiltration is typically in the range of 10-20 inches per year. Using a mid-range estimate of 15 inches per year over the approximately 26 acres of the site, and assuming flow through the underlying aquitard (marine tidal marsh deposits and glacial till) is negligible, the lateral flow would be on the order of 20 gallons per minute (gpm).

The overburden water bearing zone is separated from the underlying bedrock water bearing zone by the combined aquitard represented by the organic silt and clay fraction of the marine tidal marsh deposits and the glacial till. The measured hydraulic conductivity data for the glacial till, as reported in the RI ranged from 3.5×10^{-7} cm/sec to 1.5×10^{-6} cm/sec. The RI also calculated a probable maximum hydraulic conductivity of the combined tidal marsh deposits/glacial till aquitard using Darcy's Law and an estimate of vertical recharge (16 inches per year), resulting in a geometric mean estimate of 1.3×10^{-5} cm/sec. These data indicate that the aquitard will provide a degree of hydraulic separation between the overburden water-bearing zone and the underlying bedrock aquifer.

The bedrock water bearing zone at the Site is part of a regional aquifer within the Passaic Formation. In the vicinity of the Site, however, this water bearing zone contains high levels of dissolved solids (salts), most of which are naturally occurring as result of the interconnection with the brackish Arthur Kill. The bedrock water-bearing zone at the Site has been reclassified to a IIIB designation (not suitable for potable use), as confirmed by the NJDEP in a letter dated February 27, 2009.

Figures 2-3 and 2-4 illustrate groundwater flow in the bedrock water bearing zone. Figure 2-3 has been recreated from the RI and represents the bedrock water-bearing zone potentiometric surface under conditions where groundwater extraction from the remediation system on the adjacent LPH property is not operational. As shown on Figure 2-3, the potentiometric surface is consistent with the regional pattern of groundwater flow towards the Arthur Kill, as flow is generally in an east-southeast direction across the LCP Site. Figure 2-3 also indicates a slight groundwater mound coinciding with the central portion of the LCP Site, which could be a reflection of increased infiltration from the overburden mound, from variability of the aquitard hydraulic conductivity, or from building foundation pile penetrations.

Figure 2-4 illustrates the bedrock water-bearing zone potentiometric surface under conditions where the groundwater extraction system on the LPH property is operational and groundwater is being pumped from extraction well DEW-4A, which is the nearest extraction well to the LCP Site. Figure 2-4 has also been recreated from the RI. As the potentiometric contours in Figure 2-4 illustrate, flow has been reversed from that shown in Figure 2-3 as a result of pumping on the adjacent LPH property. The flow reversal results in capture of groundwater in the bedrock water-bearing zone beneath the majority of the LCP Site. This capture zone and the groundwater effects from the adjacent LPH site, as discussed further below, are taken into consideration when evaluating groundwater conditions in the bedrock, because the LPH property groundwater extraction system will remain operational for a time period expected to be consistent with the remediation time frame for the LCP Site as well.

2.3 Nature and Extent of Contamination

2.3.1 Soils

As previously described, the Site is covered by a layer of fill material (anthropogenic fill) which overlies naturally occurring tidal marsh deposits and glacial till, which deposits overlie bedrock. Constituent concentrations within anthropogenic fill, tidal marsh deposits and glacial till have been compared to the New Jersey Non-Residential Direct Contact Soil Remediation Standards (NRDCSRS). The NRDCSRS are promulgated remediation standards (N.J.A.C. 7:26D) that are based on theoretical exposures via accidental human ingestion, dermal contact, and/or inhalation of soils. The NRDCSRS represent concentrations below which NJDEP would not have concern about incidental human exposure under a non-residential scenario. Given the nature and character of the LCP Site and surrounding area, use of non-residential criteria is considered appropriate.

The anthropogenic fill is continuous across the Site with an average thickness of approximately 9 feet. The fill consists of an irregular mixture that is primarily comprised of soil but is characterized by the frequent presence of anthropogenic materials, including ash, wood fragments, bricks, and glass. Various constituents, including arsenic, mercury, PCBs, PAHs and to a lesser extent lead and hexachlorobenzene are found frequently throughout the fill material at concentrations above the NRDCSRS. Other constituents, including cadmium, cobalt, and occasional VOCs and SVOCs, are also present above the NRDCSRS, although their presence is not as widespread as the constituents identified above. Potential 'free product" referenced in the earlier site work performed as a part of the Site Characterization Summary Report was further evaluated during the RI. Visual identification of possible residual saturation of unidentified organic liquids was made in a number of soil samples during the RI, and was generally characterized by the presence of oily material smudge. This material is not widely distributed across the site. The soil laboratory analysis data in the RI also yielded no additional information regarding this material. No free phase liquids were observed in monitoring wells. Overall, free product is not evidenced at the Site, but rather some limited residual saturation has been observed.

Mercury was measured in the surficial fill from non-detect to 7,870 mg/kg, with more than half of the detections above the NRDCSRS. However, mercury concentrations were attenuated with depth, as for example, only 5 of 28 samples tested in the marine tidal marsh deposits had mercury concentrations above the NRDCSRS. The presence of mercury in soils is related to the former manufacturing operations at the site. PCBs were also detected in the former production area, and while not directly related to chlor-alkali production, may have been related to the electrical equipment associated with the production. Other constituents which can be associated with chlor-alkali production include polychlorinated dibenzo-p-furans (PCDF), polychlorinated naphthalenes, and hexachlorobenzene. Toxic Equivalency Factors (TEFs) are assigned to PCDFs (and PCDDs – polychlorinated dibenzo-p-dioxins) relative to the toxicity of 2,3,7.8-PCDD. The TEFs are used to develop a Toxicity Equivalency Quotient (TEQ) which is the sum of the quantity of each individual PCDF/PCDD's respective TEF. TEQs allow the comparison of the relative risk of exposure in areas of contamination that vary widely in the composition and level of these compounds. TEQ values were calculated for PCDF/PCDD, however all the TEQs were less than 1.0 µg/kg (ppb), ranging from 0.00002 to 0.885 µg/kg. Similarly, the class of compounds identified as Polychlorinated Naphthalenes (PCNs) are considered to be "dioxin like" and the more toxicologically significant higher chlorinated congeners have been associated with other chlor-alkali sites. However, these higher chlorinated congeners have not been detected at the LCP Site. The total PCN concentrations for the lower chlorinated congeners ranged from 0.007 mg/kg to 76.8 mg/kg in the surficial fill and 0.012 mg/kg to 19.2 mg/kg in the deep fill. Although low levels of PCNs were also detected in several tidal marsh deposits and glacial till samples, the concentrations were considerably lower than detected in shallower soils. Hexachlorobenzene was detected in surficial soils above the NRDCSRS, principally in areas of former production and appears to be related to the former chlor-alkali production. In general, the various compounds which can be associated with chlor-alkali production or may have otherwise been associated with site operations (e.g., PCBs from electrical equipment) are co-located with mercury.

Arsenic, which is not related to chlor-alkali manufacturing operations, is present in upland surficial fill at an average concentration of 16 mg/kg (maximum 335 mg/kg). Arsenic is relatively heterogeneously distributed in the fill (see Figures 6-2a and 6-2b of the RI (included in Appendix A for reference)) and shows no "hot spots" or other areas with elevated arsenic (with the exception of a few locations in the Linde area on the western portion of the site, which is not close to South Branch Creek), consistent with the known presence of constituents such as arsenic in historic/anthropogenic fill material. The low marsh and sediment soils, however, exhibit higher arsenic concentrations; up to 5,460 in low marsh soils and up to 4,250 mg/kg in sediments. These concentrations cannot be completely explained by the presence of low-level arsenic throughout the upland fill areas of the site. A review of Figures 6-5a through 6-5d for PAHs similarly shows no pattern or distribution associated with past Site operations. The remaining constituents were typically found most frequently and at higher concentrations in the shallow fill material and less frequently and at lower concentrations with depth. A summary table of constituent concentrations exceeding the NRDCSRS in the fill is presented in RI Tables 6-2a and 6-2b, attached in Appendix A.

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Arsenic and PAHs were detected above the NRDCSRS throughout the full thickness of the fill material with no apparent decreasing concentration gradient with depth. This is consistent with the known presence of these constituents in historic/anthropogenic fill material (NJAC 7:26E, Appendix D). For instance, Figures 6-2a through 6-2d in the RI (included in Appendix A for reference) show arsenic distribution throughout the LCP property, and the locations where arsenic is found above the NRDCSRS have no relationship to the operations at the LCP Site.

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Marine tidal marsh deposits underlay the anthropogenic fill throughout the entire Site at an approximate thickness between 5 to 10.5 feet. Below the tidal marsh deposits are glacial till deposits throughout the entire Site at an approximate thickness between 18.5 and 20.5 feet. Concentrations of constituents above the NRDCSRS in the underlying tidal marsh and glacial till deposits are provided in RI Tables 6-2c and 6-2d, attached in Appendix A. As indicated by these tables, the number of constituents and sample locations where concentrations of constituents are found above the NRDCSRS is considerably less than that within the fill.

A composite map illustrating the boring locations within Site overburden materials (i.e., fill, tidal marsh deposits, and glacial till) at which one or more constituents exceeded the NRDCSRS is provided in Figure 2-5, which indicates concentrations of various constituents above the NRDCSRS are widely distributed across the entire Site with no discernable distribution pattern. This is not to say that past Site operations did not have an influence on the nature and extent of contamination in soils, as previously noted. For instance, as described above, mercury is found most frequently and at the highest concentrations (sometimes visible mercury) in soils around and beneath the former mercury cell buildings. Rather, Figure 2-5 helps to illustrate that two circumstances have been contributors to the nature and extent of contamination at the Site. One is the anthropogenic fill which represents a heterogeneous and site-wide source of contamination. The other is the on-Site operations, which have resulted in contamination correlated to prior site activities, most notably mercury in and around the former cell buildings, and manifested in the sediments in South Branch Creek.

Visible elemental mercury was reported at 31 sample locations within the vicinity of the former production area, which are presented in RI Table 6-3, attached in Appendix A. In addition, mercury has been observed at the ground surface in apparent response to rainfall events, likely as a result of capillary action as soil pores become saturated with water and the surface tension exhibited by mercury (i.e., mercury has a greater affinity for itself than as a wetting fluid for the soil). Evidence of mercury on the ground surface, coupled with the knowledge that the frequency of visible elemental mercury and the concentration of total mercury within the analytical samples decreases with depth, suggests that downward migration of elemental mercury as a result of its density is not a significant factor at the LCP Site. However, visible mercury was reported in two of the glacial till samples collected from horizontal borings beneath Building 240. These findings suggest that elemental mercury may sporadically migrate downward along vertical features such as building piles. Locations at which elemental mercury was observed either in soil borings or observed on the ground surface are illustrated in Figure 2-5, referenced above. As shown in Figure 2-5, observations of visible elemental mercury occur around the former cell buildings, and are also co-located with exceedances of NRDCSRS for various other constituents.

For the purpose of this FS, visible elemental mercury in soil is considered here to be principal threat waste. Principal threat wastes are generally defined as wastes such as drummed liquids or NAPLs, mobile source materials (e.g., high concentrations of soluble contaminants) or highly toxic source materials (e.g., buried wastes or soils with "significant" (USEPA, 1991) concentrations of highly toxic materials). Mercury is considered a persistent, bioaccumulative, and toxic substance which does not readily degrade in the environment. As described in Section 2.3.3, elemental mercury at the site, including visible elemental mercury, has not been found to be mobile at the Site. The visible elemental mercury does represent a potential continuing source at "significant" concentrations in soil, represents a source to the potential direct contact and vapor exposure pathways, and as discussed in Section 2.5 is a principal contributor to potential site risks. The volume of soil containing visible elemental mercury is further discussed in Section 2.7.

Mercury speciation testing was conducted on six selected surficial soil samples to determine the relative mobility of mercury found at the Site (Results of mercury speciation testing are presented in RI Table 6-5, attached in Appendix A). Results of this testing indicate that the mercury present in the surficial soils is primarily in low solubility/insoluble forms including elemental (metallic) mercury and mercuric sulfide (metacinnabar). The occurrence of these low solubility/insoluble mercury species indicates that mercury in the Site soils is relatively immobile, and principally present in stable forms. The low mobility of the mercury in the Site soils is evidenced by the relative absence of mercury in overburden groundwater. Despite the widespread presence of mercury in overburden soils, including visible mercury at 31 locations as noted above, only two wells, MW-23S and MW-24S, had dissolved concentrations of mercury above the NJ groundwater quality standard of 2 ug/L.

The RI also looked at various classes of compounds for comparison against other criteria, as applicable. Individual constituents identified as PCBs and PAHs are addressed by the NRDCSRS. Carcinogenic PAHs (cPAHs) consist of eight specific, high-molecular weight PAHs that are designated by USEPA as possible human carcinogens. Benzo(a)pyrene (B(a)P) is the most completely studied of the possibly carcinogenic PAHs and exhibits the highest relative toxicity. TEQ values for the cPAHs ranged from non-detectable to 102 mg/kg and the detectable concentrations are widely distributed across the entire Site with no discernable distribution pattern, and most likely are associated with the anthropogenic fill. BTEX compounds were also detected in the Site soils, but typically at low levels and only benzene above the NRDCSRS. These compounds may be associated with localized spills of fuel or oil or with the anthropogenic fill. Chlorobenzene was also detected in the Site soils below NRDCSRS, and are not associated with chlor-alkali production. However, chlorobenzene was used in the operations on the adjacent LPH and NOPCO sites.

Finally, Toxicity Characteristic Leaching Procedure (TCLP) testing was performed on four samples to assess whether site soils could be classified as a characteristic hazardous waste, if managed as part of implementation of a remedy. Of the four samples tested, two would be considered a characteristic hazardous waste (exceeding the limit of 0.2 mg/L mercury in TCLP extract) and two would not. The TCLP results did not correlate with mercury concentrations in the soil samples or the presence of visible mercury.

2.3.2 Soil Vapor

Soil vapor samples were collected from shallow soil vapor probes at representative locations across the Site as illustrated in Figure 2-6. Ten samples (probe locations) were tested for VOCs and four samples (probes) were tested for mercury. Mercury was detected in each of the four samples tested with concentrations ranging from 0.2 to 2.5 ug/m3. There is no soil gas screening level for mercury.

The VOCs detected in the soil vapor are similar to those that were detected in the soil. The VOCs in soil vapor include chlorobenzene, BTEX compounds, hexachlorobutadiene, chloroform and TCE. A comparison to New Jersey Soil Gas Screening Levels-Non-Residential (NJSGSLNR, NJDEP, 2005) reveals a total of 15 exceedances, of five separate constituents, as summarized in RI Table 6-23, attached in Appendix A. The exceedances were from various soil vapor probes located along the railroad tracks and the western portion of the site, as well as the central portion west of Building Nos. 230 and 240.

2.3.3 Groundwater

As described previously, groundwater at the LCP Site is found within the overburden water-bearing zone contained within the fill material and peat subunit of the tidal marsh deposits and within the upper portion of the Passaic Formation bedrock identified as the bedrock water-bearing zone. These two water-bearing zones are separated by an aquitard consisting of the organic silt and clay subunit of the tidal marsh deposits and the glacial till.

Given its naturally saline condition, groundwater, within the bedrock water-bearing zone is not utilized as a resource by public or private water-supply wells within the vicinity of the site. Bedrock groundwater beneath the Site was re-classified as Class III-B by the NJDEP in a letter dated February 27, 2009. The overburden water-bearing zone at the LCP Site, however, does not meet all of the requirements under NJAC 7:9C-1.5 for reclassification to Class III-B and is thus considered a Class IIA water-bearing zone (confirmed in a letter from the NJDEP dated October 30, 2008).

Deleted: However, the overburden groundwater at the Site is also not utilized as a resource for public or private water supply as it is present in the anthropogenic fill and its shallow depth would not permit construction of a well per NJAC 7:9D, which requires a minimum of 50 feet of casing.

Water quality within the overburden and bedrock water-bearing zones has been evaluated in the RI through the collection of water quality samples obtained from monitoring wells completed within each of the water-bearing units. Water quality data for the overburden water-bearing zone is then compared to the Class IIA water quality standards. The bedrock water-bearing zone is classified as a Class IIIB Aquifer and, therefore, comparison to published water quality criteria is not applicable. Rather, Class IIIB Aquifers that discharge to surface water, as is the case at the LCP site, are regulated so as not to exceed New Jersey Surface Water Quality Standards applicable to that water body (N.J.A.C. 7:9-6.7(g)). Therefore, the down-gradient bedrock wells closest to the surface water discharge point are compared to the saline surface water criteria. Criteria applicable to the interior bedrock wells is not available and these data are, therefore, discussed in more general terms.

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Comparison of the overburden water quality data to Class IIA criteria is presented in Table 2-1. Figures 2-7, 2-8, 2-9, and 2-10 illustrate the distribution of site-specific constituents, VOCs, SVOCs, and metals in overburden groundwater with concentrations above the Class IIA criteria. Mercury, the principal site-related constituent, was found in only two wells above the Class IIA groundwater quality standards. Several VOCs and SVOCs are present in the overburden groundwater at concentrations above Class IIA water quality criteria, as are various metals. Dissolved mercury is detected within the central portions of the Site (overburden monitoring wells, MW-23S and MW-24S) with concentrations decreasing in the down-gradient direction toward South Branch Creek and the unnamed tidal ditch that borders the LCP Site to the south. Dissolved mercury was not detected in the overburden samples closest to surface water bodies, with the exception of MW-14S, which had a trace of mercury (0.39 µg/L, well below the groundwater standard of 2 µg/L). Metals consisting of arsenic, iron, manganese and sodium were reported above the Class IIA criteria at overburden monitoring wells located throughout the site. VOCs detected most frequently and at the highest concentrations included benzene and chlorobenzene. Several SVOCs were also detected above the Class IIA water quality standards. These groundwater quality data do not indicate any discernible patterns or plume associated with the former Site operations, as illustrated in Figures 2-8 through 2-10. Rather the data indicate that the factors contributing to overburden water quality include influence from Site operations (e.g., mercury in wells MW-23S and MW-24S), influence from the anthropogenic fill (e.g., various SVOCs), and influence from adjacent site operations (e.g., chlorobenzene from the LPH and NOPCO sites).

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As noted above, the bedrock water-bearing zone is classified as a Class IIIB aquifer and, therefore, published numeric water quality criteria are not available for comparison. Rather, Class IIIB groundwater quality criteria are defined at N.J.A.C. 7:9C-1.7(f) as follows:

"…the criteria shall be no more stringent than necessary to ensure that there will be no:

1. Impairment of existing uses of ground water;
2. Resulting violation of Surface Water Quality Standards;
3. Release of pollutants to the ground surface, structures or air in concentrations that pose a threat to human health;
4. Violation of constituent standards for down gradient classification areas to which there is a significant potential for migration of ground water pollutants."

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Each of these criteria is discussed further below.

Criterion No. 1

As reported in the RI, Section 2.8, potable water in the site vicinity is provided by New Jersey American Water. There are no water supply wells down-gradient of the site, and the brackish nature of the bedrock aquifer in the vicinity of the Arthur Kill limits groundwater use in the area. As such, there are no existing uses of the Class IIIB aquifer which could be impaired by the site.

Criterion No. 2

As noted in N.J.A.C. 7:9C-1.7(f)2, Class IIIB Aquifers that discharge to surface water, as is the case at the LCP site, are regulated so as not to exceed Surface Water Quality Criteria applicable to that water body (N.J.A.C. 7:9-6.7(g)). Data for wells along the down-gradient perimeter of the site, closest to the surface water discharge point (MW-25D, MW6D and MW-21D) are compared to saline surface water criteria in Table 2-2. As shown in Table 2-2, only arsenic in MW-25D and manganese in each of the three wells are found in concentrations above any of the surface water quality criteria. These constituents are most likely associated with the fill or are naturally occurring (i.e., manganese). The data, therefore, do not indicate the potential for an impact on surface water quality from groundwater discharge from the bedrock.

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Bedrock groundwater quality data are summarized in Table 2-3 (detections), with representative constituents (mercury, chlorobenzene, benzene), and their respective concentrations, illustrated in Figure 2-11. These representative constituents are the most commonly detected in the bedrock groundwater and while other miscellaneous compounds are detected, these constituents help to illustrate groundwater quality impacts in the bedrock water bearing zone. Review of the figures illustrates that the higher concentrations of chlorobenzene and mercury, in particular, are found in wells north and west of the former production area within the up-gradient portion of the Site. By contrast, as shown on Figure 2-5, mercury in the overburden soils predominates in the former production area, and as previously mentioned, is principally present as low solubility/insoluble species not generally manifested in overburden groundwater. Chlorobenzene is not associated with the LCP Site, and shows a similar pattern of distribution; highest concentrations in the northwestern, up-gradient portion of the Site. Constituent concentrations decrease significantly under the central portion of the Site and are at trace or non-detectable levels along the down-gradient property boundary adjacent to surface water.

This distribution of groundwater quality impacts is indicative of impacts associated with the adjacent LPH site and is not associated with LCP. Chlorobenzene is associated with the adjacent LPH site, as is more soluble mercury. When viewed in the context of the bedrock water-bearing zone potentiometric surface illustrated in Figure 2-4, the groundwater quality data show that the origin of the groundwater quality impacts is from up-gradient and is not associated with the LCP Site. Following the groundwater flow paths illustrated on Figure 2-4, one sees that groundwater flows on to the LCP site, sweeps to the southeast and then is caught up in the flow path toward the LPH groundwater extraction well DEW-4A. These flow paths are consistent with where constituents such as chlorobenzene and mercury are detected (MW-17D, MW-18D, and MW-20D). The only bedrock wells that contain detectable levels of mercury are located northwest of the LCP production area. Groundwater in the bedrock water-bearing zone is being re-captured and subsequently treated by the LPH remediation system.

Metals, including aluminum, arsenic, iron, lead, manganese, selenium, and sodium are found throughout the bedrock water-bearing zone, with the highest concentrations again attributable to the interior portions of the site. However, as previously noted, the farthest down gradient wells closest to surface water, namely MW-6D, MW-21D and MW-25D, have concentrations of only arsenic (MW-25D, 8.7 ug/l) and manganese (MW-6D, MW-21D and MW-25D at 2240, 4250 and 3820 ug/l respectively) above surface water quality criteria. These concentrations are above human health criteria only and there are no exceedances of the aquatic criterion for arsenic, and manganese does not have an aquatic criterion. These constituents are not associated with historic operations, and may also be naturally occurring (manganese) or associated with anthropogenic fill (arsenic) on the Site.

Criterion No. 3

The bedrock aquifer does not discharge locally other than into the Arthur Kill, the ultimate point of discharge. The potential for impacts to the Arthur Kill is addressed by the assessment of the groundwater by comparison to surface water quality standards as described above. With the only discharge being to the Arthur Kill, there is no mechanism for a release of pollutants to the ground surface, structures, or air from the bedrock aquifer.

Criterion No. 4

Last, because the bedrock aquifer discharges to the Arthur Kill, the ultimate groundwater discharge point, there are no other down-gradient groundwater classification areas that could be impacted by the Site.

2.3.4 Sediment

Sediment samples were collected along five transects located in South Branch Creek, two transects in the Arthur Kill near the mouth of South Branch Creek, and three transects in both the Northern and Southern Off-Site Ditches. Nine additional samples were collected in the Phase I RI in the upper six-inch interval of the South Branch Creek sediments. Arsenic, mercury and total PCBs, were detected at the highest concentrations and represent the most frequently reported constituents.

Mercury speciation testing was also conducted on seven sediment samples from South Branch Creek. Results from this testing are presented in RI Table 6-35, attached in Appendix A, and are similar to the on-site surficial soil results in that elemental mercury and mercuric sulfide are the predominant forms of mercury (i.e., low solubility and low mobility forms of mercury).

There are no promulgated regulatory standards for sediment quality. However, the ER-L (Effects Range Low) and ER-M (Effects Range Median) screening values (Long, *et al.*, 1995) are used to provide a context for assessing the sediment data. These screening levels were selected from among several sets of frequently cited benchmarks because they are preferred by the NJDEP (NJDEP, 1998). The ER-Ls and ER-Ms represent the 10^{th} and 50^{th} percentile concentrations, respectively, associated with observed biological effects from systems with multiple contaminants. The ER-Ls are used as a threshold below which biological effects are not expected. The ER-Ms are indicators of when effects might be expected. The ER-Ms do not indicate biological hazard, only that additional risk evaluation may be warranted. RI Tables 6-33a and 6-33b, attached in Appendix A, list the ER-L and ER-M values for various constituents, along with locations with concentrations above these screening values for South Branch Creek, Arthur Kill and Off-Site Ditch sediments.

Also summarized in RI Table 6-18a, attached in Appendix A are constituent concentrations above the NRDCSRS in the soils identified in the RI as “Low Marsh Soils”. As described more fully in the RI, these soils likely represent sediment that has been deposited along the bank, and/or in part, the geologic surface exposure or “outcrop” of the tidal marsh deposits within the low lying areas of the Site adjacent to South Branch Creek and the Arthur Kill. A composite map illustrating the locations at which one or more constituents exceeded the ER-L (sediment) or NRDCSRS (low marsh soils) is provided in Figure 2-12.

In addition to the above, a regional study was performed in Old Place Creek in Staten Island, New York, a tributary of the Arthur Kill following the same methods and procedures as used during the LCP Phase II RI. These data, along with published information, were then used as a point of comparison. And, sediment toxicity testing was performed, indicating that the Site-related sediment sample exhibited acute toxicity in analyzed samples (two samples were not tested because of the presence of mercury vapors).

Mercury present throughout South Branch Creek and the Northern Off-Site Ditch sediment is site related. Shallow groundwater in the vicinity contains little or no mercury, so sources are historically related to direct discharges and surface run-off. There is no substantial ongoing drainage from the site to South Branch Creek. Given the lack of drainage improvements along the southern property line of the LCP Site, it is likely that stormwater, and solids carried in the stormwater, would have drained from the LCP Site in the direction of the Northern Off-Site Ditch during a major storm event. The mercury results of the two off-site ditches indicate that the Northern Off-Site ditch has received runoff and solids contained within the runoff, from the LCP Site, while the southern ditch has not.

Mercury appears in suspended particulates in surface water as well as low marsh soil, which has likely been impacted by upland sediment deposition. Mercury concentrations are highest in the areas of historical inputs. There is a pattern of generally declining mercury concentrations in surficial sediment along South Branch Creek toward the Arthur Kill. Other constituents reported in South Branch Creek sediments are low-level PCBs, PCDFs, and chlorinated benzenes, all of which show a similar gradient leading toward the Arthur Kill. The concentration gradients of various contaminants found in the Northern Off-Site Ditch (i.e., mercury, arsenic, other metals, PAHs and chlorinated benzenes) are less defined due to the parallel configuration of the Ditch alongside the operations area of the Site. The overall concentrations of mercury in the Northern Off-Site Ditch were elevated, averaging 90.2 mg/kg, although they were generally lower than those found in South Branch Creek. Concentrations of mercury in the Southern Off-Site Ditch were significantly lower, averaging 1.29 mg/kg.

The headwater area of South Branch Creek is clearly impacted by elevated arsenic. However, the arsenic enrichment appears to be a relatively isolated condition, as arsenic concentrations decline rapidly with distance from the headwater. This apparent arsenic hot-spot does not likely result from on-site sources. Arsenic is not associated with chlor-alkali facilities and the sediment concentrations are considerably higher than arsenic levels observed in site soils within the former LCP production area. These data suggest that the source of arsenic in this area may have originated from another off-site source, possibly as a result of overland flow in the swale along the railroad tracks from the

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Deleted: Arsenic concentrations in sediment and low marsh soil are elevated in the up-gradient area, but the elevated levels relative to those detected on site indicate that arsenic is present due to non-Site sources (historic drainage along the railroad tracks from other sites).

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duPont and GAF sites. Arsenic concentrations in the Northern Off-Site Ditch, while lower than that found in South Branch Creek, are elevated beyond those found in the Arthur Kill, indicating historic discharge to the Ditch. The highest concentrations of Arsenic in surficial soils on the LCP Site were found in the vicinity of the former Linde Hydrogen Plant, located north of the ditch, indicating runoff from this area of the Site may have impacted the Northern Off-Site Ditch. Other contaminants (e.g., metals, PAHs) show minimal relationship to the Site and appear to be of regional origin.

Moved up [7]: Arsenic impacts also attenuate with distance along South Branch Creek, reflecting the generally low sediment mobility in the ditch.

Sediments in the Southern Off-Site Ditch do not appear to have been impacted by contaminants relating to the LCP Site as it does not appear that the ditch would receive stormwater run-off from the LCP Site, as the ditch is not physically connected to the Site, and the unpaved road between the ditches would act as a physical barrier to drainage between the ditches. Additionally the Southern Off-Site Ditch receives tidal influx directly from the Arthur Kill, as opposed to South Branch Creek. The concentrations of contaminants in the Southern Off-Site Ditch are significantly lower than those found in the Northern Off-Site Ditch or South Branch Creek, and are more similar to regional conditions found in the Arthur Kill.

2.3.5 Surface Water

Surface water was characterized in a manner similar to sediments by collecting samples at each of the five sediment transects located in South Branch Creek along with two locations in the Arthur Kill and from two locations in each Off-Site Ditch In addition, surface water samples were collected during a complete tidal cycle to assess the potential transport of contaminants, given the tidal exchange within South Branch Creek (i.e., different surface water quality results during ebb and flow).

Mercury was detected in surface water, but as a consequence of sediment suspension. Mercury was not detected in filtered surface water samples. Similar to sediments, arsenic is also found in surface water, but is likely related to non-Site sources. Other organics and inorganics were detected but at either trace levels, showing little correlation to the Site, or are co-located with the predominant Site constituent – mercury. Surface water quality data are summarized in RI Table 6-30, attached for reference in Appendix A.

2.3.6 Biota

Fish and crab samples were collected during the RI from both South Branch Creek and the Arthur Kill. Mercury in tissue samples generally paralleled the results of the sediment samples, showing higher levels nearer the site and declining to regional levels at the Arthur Kill. The comparability of the patterns of mercury in fish tissue and sediment reflects the low mobility of this fish species and is consistent with bioaccumulation from the sediment in the immediate habitat area. Arsenic concentrations in tissue samples correlated with the location of elevated arsenic concentrations in sediment. The tissue data and arsenic speciation indicated that the form of arsenic associated with the headwaters area appears to be some organic form not commonly found. As described in more detail in the RI and as noted above, the headwaters area of South Branch Creek has historically received drainage from the duPont and GAF sites, which are known to have used and potentially discharged arsenicals. It is therefore entirely plausible that the arsenic present in the fish in this area of markedly elevated arsenic concentrations in sediment have accumulated an arsenical that is not commonly found. Other metals found in tissue samples did not exhibit a discernible concentration pattern, and PCBs were generally found comparable to regional levels.

Deleted: The mercury present in tissue samples of organisms collected in SBC was elevated by comparison to background in the Old Place Creek samples.

Deleted: , and the tissue data for arsenic also indicated an unrelated off-site source other than the LCP Site (e.g., the unique form of arsenic found in a tissue sample upon speciation)

2.4 Contaminant Fate and Transport

The fate and transport mechanisms for the contaminants of potential concern (COPCs) identified at the LCP Site are summarized below for the media of interest. Reference should be made to the RI for a detailed discussion of fate and transport mechanisms. The Site COPCs are discussed in more detail in Section 2.6.

The fate and transport of COPCs within soils can be influenced by volatilization, suspension (in air or water), adsorption (binding to soils and particulate matter), solubilization (aqueous solubility), density driven migration and transformation/biodegradation, with each COPC behaving differently depending on its individual properties. Bioaccumulation may also be a factor in soils but is principally associated with sediments.

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The fate and transport of COPCs within groundwater is principally affected by advection (movement with groundwater), adsorption (on to the soil matrix or particulate matter), transformation (chemically or biologically), and biodegradation.

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The fate and transport of COPCs in sediment is related to adsorption, suspension and bioaccumulation (e.g., from benthic invertebrates to higher trophic levels).

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For the LCP Site, the key conclusions regarding fate and transport are:

- Mercury is present principally as insoluble/low solubility species (elemental and mercuric sulfide) as evidenced by dissolved mercury concentrations above groundwater quality standards in overburden groundwater at only two wells, despite the presence of visible elemental mercury in the former operations area.

- Elemental mercury and mercuric sulfide are generally quite stable over a range of environmental conditions.

- As previously described, lateral transport (advection) of contaminants is not significant adjacent to the surface water bodies, with only manganese and arsenic found in concentrations above human health based, but not above aquatic based criteria adjacent to the Arthur Kill.

- Various other contaminants are present either as a result of former operations or from the presence of anthropogenic fill, will vary in fate and transport properties based on the individual constituent, but none demonstrate consistent patterns throughout the site (e.g., groundwater plume).

2.5 Baseline Risk Assessment

A Human Health Risk Assessment (HHRA) and Baseline Ecological Risk assessment (BERA) were completed as part of the RI work and the findings are summarized below.

2.5.1 Human Health Risk Assessment

The Human Health Risk Assessment (HHRA) evaluated the potential exposure of human receptors to constituents detected in environmental media at the LCP Site. The objectives of the HHRA were to determine whether chemicals of potential concern (COPCs) present in environmental media at the Site pose unacceptable risks to human health under current and reasonably anticipated future land use, and to provide information to support decisions concerning the need for remedial action.

Human exposures to Site media are currently limited since the Site is unoccupied and not used for any operational purpose. The majority of the Site is surrounded by perimeter fencing and secured gates. Groundwater is not used for potable or other purposes. Therefore, exposure to soil, shallow groundwater and indoor air (via vapor intrusion) under current conditions are incomplete exposure pathways.

The HHRA resulted in the following conclusions:

- Areas with visible elemental mercury are assumed to present an unacceptable risk for future commercial/industrial, site-specific, and construction/utility workers based on potential direct contact and vapor pathways under current, unremediated conditions. Areas of visible elemental mercury contamination, however, could not be quantitatively evaluated.

- Future use potential cumulative cancer risks from exposure to soil via ingestion, dermal contact, and vapor/particulate inhalation are within the USEPA acceptable risk levels for future site-specific, construction/utility, and future commercial/industrial workers under a central tendency exposure (CTE) scenario. Under a reasonable maximum exposure (RME) scenario, this was also the case with the exception of future commercial/industrial workers. Hexachlorobenzene, PAHs, furans, PCBs, and arsenic made the greatest contributions to overall potential cancer risk.

- Future use potential non-cancer risk estimates for direct exposure via the same pathways as used for the cancer risk estimates, exceeded the benchmark value of 1 for future commercial/industrial, site-specific, and construction/utility workers under both CTE and RME scenarios. The inhalation of elemental mercury and the ingestion of inorganic mercury made the most significant contributions to potential overall non-cancer risk.

- Future use of groundwater is unlikely due to salinity (bedrock groundwater is classified IIIB) and regulatory restrictions (e.g., overburden is too shallow). The overburden groundwater is classified as IIA, however, and therefore, a future use scenario of commercial/industrial worker ingestion was assessed. Under this scenario, cancer risks exceeded USEPA acceptable risk levels and non-cancer risks exceeded the benchmark value of 1. Arsenic, mercury, benzene, p-chloroaniline, and various metals were the primary contributors to the potential excess risk.

- Future construction/utility worker potential cumulative cancer risks from exposure to groundwater via dermal contact were within the USEPA acceptable risk levels. Cumulative potential non-cancer risks for this exposure scenario exceeded the benchmark value of 1.

- Concentrations of lead in soil are not expected to result in adverse health effects under the future commercial/industrial and site-specific worker exposure scenarios for surface soil, future construction /utility workers exposure scenario for mixed soil, and trespassers exposure scenario for sediment/bank soil in South Branch Creek.

- Under future use scenarios for vapor intrusion, mercury and VOCs may be present at concentrations that are above health-based criteria for industrial/commercial receptors. The primary contributors under this scenario are elemental mercury and to a lesser extent hexachlorobutadiene and chloroform.

- Potential cancer and non-cancer risk estimates for current and future adolescent trespassers exposed to sediment/bank soils in South Branch Creek were within the USEPA acceptable risk levels.

Overall, potential non-cancer risks in soil and soil vapor were driven by mercury, and potential non-cancer risks in groundwater were driven by furans and manganese. Potential cancer risks in soil were driven by arsenic, PCBs, furans, carcinogenic PAHs, and hexachlorobenzene, but potential excess risk exceeded the USEPA acceptable risk levels only in the RME scenario for future commercial/industrial works. Potential cancer risks in groundwater were driven by arsenic and benzene. Several of the chemicals that contribute to potential future risk are believed to be associated with the fill at the Site or are found regionally in soils.

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2.5.2 Ecological Risk Assessment

Several ecological exposure pathways were determined to be complete and were evaluated in the Baseline Ecological Risk Assessment (BERA). Current conditions do not provide an attractive habitat for a wide variety of receptors. However, risks were developed for receptors that could inhabit the Site in the future.

Exposure to animals was assumed to occur via the ingestion of contaminated prey and due to incidental ingestion of substrate while feeding and grooming:

The BERA resulted in the following conclusions:

- Ecological risks for upper trophic-level receptors (raccoons and great blue herons) exposed to COPECs in South Branch Creek are generally below established risk benchmarks of 1. However, there is a potential for limited ecological risk for the great blue heron.
- Several COPECs in upland soil have the potential to result in adverse ecological effects to mammalian insectivores. However, ecological exposure to terrestrial soil is not considered a significant pathway given the highly disturbed habitat, lack of prey species and vegetation, and limited accessible soil due to buildings, pavement and gravel on site.
- Areas of visible elemental mercury contamination, located around the former production areas, could not be quantitatively evaluated; however, for the purposes of the BERA, these areas were assumed to present an unacceptable risk to current/future terrestrial wildlife receptors.

- Elevated risks are predicted for benthic invertebrates in South Branch Creek.
- Principal ecological concerns are for benthic macroinvertebrates in sediments in South Branch Creek.

2.6 Summary of Contaminants of Potential Concern

The preceding sections summarize the distribution, fate, transport, and baseline risk assessment for the various contaminants found at the site related to site operations, adjacent properties/operations, and the anthropogenic fill. As noted in the preceding sections, a number of contaminants are present at the site above comparative standards (e.g., NJ Non-Residential Soil Remediation Standards) or guidance levels (e.g., sediment ER-Ls), or have been identified with baseline risk levels above benchmarks. These various comparative criteria were used to develop a list of COPCs, which is shown in Table 2-4. Table 2-4 presents the COPCs organized as follows:

- By medium – soil, groundwater, and sediments;
- Whether associated with the chlor-alkali operations or likely from another source; and
- With the basis for listing as a COPC shown – baseline risk assessments, or comparison to a standard or guidance value.

Of note, the sediments COPCs correspond to the list generated in conjunction with the USEPA during the Baseline Ecological Risk Assessment Problem Formulation, and in some instances include naturally occurring elements (e.g., iron) that are not considered risk drivers, but that the USEPA requested be retained for the ecological risk assessment.

As described in Section 2.3.5, generally COPCs are not present in surface water, or if present are found principally as a consequence of the presence of sediment in the water column. Therefore, surface water COPCs are not included in the COPC list in Table 2-4.

2.7 Conceptual Site Model and Site Characterization Summary

Contaminants associated with the site media fall into three general categories:

- Contaminants associated with site operations: these include constituents directly resulting from the chlor-alkali processes (principally mercury, HCB, possibly PCNs and PCDFs), and those that were spilled or discharged as part of general facility operations (PCBs from electronic transformers, BTEX from fuel and lubricating oil);

Deleted: but are infrequently detected, are not risk drivers, are co-located with risk drivers, are present naturally (e.g., iron, manganese), or are present from the anthropogenic fill. Table 2-4 presents a summary of contaminants of potential concern (COPCs) that are the key risk drivers by medium and/or are detected frequently. More specifically, this condensed list of COPCs was generated by selecting contaminants:¶
With a cancer risk greater than 1E-6, and a key contributor to risk;¶
With a non-cancer hazard quotient greater than 1, and a key contributor to risk; and¶
That are frequently detected.¶
This condensed list provides the ability to focus the remedial alternatives analysis and at the same time cover the full suite of COPCs (e.g., co-located contaminants are covered by key risk drivers).

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- Contaminants that are incidental as a result of placement of contaminated anthropogenic fill or are from adjacent, off-site sources (benzene, chlorobenzenes, PAHs, most metals).
- Background conditions due to atmospheric deposition, stormwater and other discharges from non-site sources, and sediment transport from the Arthur Kill (PCDDs/PCDFs, PAHs, most metals).

Site-related contamination originated in the upland (manufacturing facility) area and primarily within the west central portion of the Site associated with the chlor-alkali operation. During the period of chlor-alkali operation, mercury (the principal COPC) was discharged to the environment atmospherically or to the ground through spills or disposal of waste. Mercury remains in soils throughout the Site, including visual evidence of elemental mercury in the area of the former production buildings. However, vertical migration of mercury in soils beneath the fill is relatively limited. The deeper fill itself contains far lower total mercury concentrations than the shallow fill. Native material underlying the fill (tidal marsh deposits and the glacial till) contains mercury below NRDCSRS in more than ¾ of the samples, indicating further attenuation.

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Relatively little mercury has partitioned into groundwater. Dissolved mercury is present in only two overburden monitoring wells, MW-23S and MW-24S, above the groundwater quality criterion of 2 ug/l, and dissolved mercury was undetected in most of the samples located between the production area and South Branch Creek or the Northern Off-Site Ditch . Only three of the bedrock groundwater samples contained detectable mercury and those are related to an off-site source which is being addressed by pumping from the adjacent LPH site. This pumping has been demonstrated to capture bedrock groundwater under the LCP site, including the area in which mercury and other constituents were detected in bedrock groundwater.

The bedrock water-bearing zone is classified as a IIIB aquifer and, therefore, comparison to published water quality criteria is not applicable (other criteria apply as well but are not relevant to this quantitative water quality discussion, see Section 2.3.3 for additional discussion). However, concentrations of VOCs, SVOCs and metals have been reported within the western portion of the Site with decreasing concentrations to the east towards the groundwater discharge point represented by the Arthur Kill. As noted above, the reported concentrations underlying the northwestern portion of the Site are attributable to the adjacent LPH site and groundwater within this area is currently being captured by the LPH site groundwater extraction and treatment system. Since Class IIIB Aquifers that discharge to surface water are regulated so as not to exceed Surface Water Quality

Criteria applicable to that water body (N.J.A.C. 7:9-6.7(g)), the down-gradient bedrock wells closest to the surface water discharge point were compared to the saline surface water criteria. This comparison indicates that the only constituents exceeding the human health criteria for saline waters were arsenic and manganese, arsenic did not exceed the aquatic criteria, and manganese does not have an aquatic criterion.

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The above soil and groundwater observations are consistent with the presence of mercury in an insoluble and low-mobility form. The results of the sequential extraction analyses performed on soils confirm that the majority of mercury exists in Site soils as the most insoluble species (primarily metacinnabar and elemental mercury). For this reason, migration of mercury in the subsurface has been limited and further migration is not anticipated.

The mercury detected in South Branch Creek (both sediments and the near-creek low marsh soils, which reflect sediment deposition during tidal surges or storm events) is likely due to historic overland releases in which soil-bound mercury moved via overland flow into the nearest surface water body. The presence of mercury in soils along the alignment of the historic South Branch Creek channel is consistent with the overland release migration mechanism. Both uncontrolled stormwater run-off and piped discharges are likely to have contributed to transport. Mercury that was atmospherically deposited to near-facility surface soils would also have subsequently been transported via run-off. Given the minimal ongoing stormwater discharge to South Branch Creek and the evidence that groundwater is a negligible source of mercury to surface water, the transport of mercury to South Branch Creek can be considered mostly historic.

Mercury in South Branch Creek sediments and adjacent low marsh soils is present at the highest concentrations in the areas closest to the former manufacturing facility and the concentrations decrease as South Branch Creek reaches the Arthur Kill. However, sediments are likely contributing to biological accumulation, as evidenced by the elevated fiddler crab concentrations. Both fish and crabs serve as prey species that can contribute to mercury biomagnifications up the food chain. Therefore, while the significance of this pathway from a bulk transport perspective is apparently limited, movement from sediment into biota is an environmentally significant potential migration pathway. Likewise, the small amount (approximately 0.1 to 0.2 percent) of mercury in surface water that has become methylated is associated with methyl mercury bioconcentration factors (BCFs) from water to fish in the 10^5 range.

PCBs, PCNs, HCB, and PCDDs/PCDFs originating in soils adjacent to the former facility would be expected to behave in a similar manner as mercury, traveling primarily via runoff adsorbed onto solids. The PCB results indicate that while there is the possibility of PCB contributions to South Branch Creek in the farthest upland transects, overall the PCB impacts are not significantly elevated beyond regional conditions present throughout the Newark Bay estuary. The range of PCBs detected in the South Branch Creek sediment samples is 0.0472–1.12 mg/kg. PCBs were not detected in Arthur Kill sediments, indicating attenuation with distance from the site. HCB movement appears to have been minimal, with only sporadic, low level detections.

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Lower-chlorinated chlorobenzenes appear to have migrated to South Branch Creek via the same mechanism of adsorption/run-off. These constituents, which have higher solubility than the other COPCs, have also partitioned into groundwater, as has benzene. A portion of what is observed in South Branch Creek may be attributable to the localized discharge of chlorobenzenes in shallow groundwater to the ditch from the MW-6 area. However, this mechanism is unlikely to account for more than a small proportion of what is observed in sediments. These more soluble COPCs have relatively short residence times in surface water due to volatilization and their higher aqueous solubility results in less partitioning to sediment. Thus relatively little benzene and chlorobenzene is observed in sediment compared with the higher-chlorinated compounds, which are more likely to have migrated adsorbed to solids.

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Various constituents, including arsenic, mercury, PCBs, PAHs and to a lesser extent lead and hexachlorobenzene are found frequently throughout the fill material at concentrations above the NRDCSRS. Other constituents, including cadmium, cobalt, and occasional VOCs and SVOCs, are also present above the NRDCSRS, although their presence is not as widespread as the constituents identified above. Arsenic and PAHs were detected above the NRDCSRS throughout the full thickness of the fill material in a relatively heterogeneous distribution that does not exhibit a relationship to the operations at the LCP Site. Exceedances are principally found within the fill material and to a lesser extent within the low marsh soils found adjacent to South Branch Creek and the Arthur Kill. The concentration and frequency of detected concentrations then attenuates rapidly within the underlying Tidal Marsh and Glacial Till deposits. Arsenic, PAHs, and metals other than mercury are not associated with site operations and their presence in soils is attributable to anthropogenic fill, regional contamination, or other historic sources. The elevated arsenic noted in sediments (concentrations greater than the maximums detected in any of the soil units) appears to be related to a local source other than the LCP site. South Branch Creek received inputs from various other sources, including the duPont site, LPH, and NOPCO.

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Drainage from the southern portion of the LCP Site, adjacent to the Northern Off-Site Ditch has remained consistent throughout the operational history at the LCP Site. The spatial distribution of mercury found in the Northern Off-Site Ditch sediments is consistent with overland migration from the former Linde Hydrogen Plant area, where mercury was detected in the fill material. The mercury concentrations, while lower than that found within South Branch Creek, are above Arthur Kill sediment and indicate historic input from the LCP Site.

The concentrations of contaminants in the Southern Off-Site Ditch are lower than those found in the Northern Off-Site Ditch or in South Branch Creek, and are similar to regional conditions found in the Arthur Kill. Based upon the analytical results of the sediment samples, the Southern Off-Site Ditch does not appear to have been impacted by contaminants relating to the LCP Site.

In summary, the LCP Site, South Branch Creek, and the Northern Off-Site Ditch are impacted with multiple contaminants, many due to the presence of anthropogenic fill and the heavily industrialized areas and not to historic Site activities. Site contamination can be summarized as follows:

- Site soils are contaminated with constituent concentrations above the NRDCSRS throughout the site. The primary soil contaminant is mercury, in particular visible elemental mercury, which has had limited impact on dissolved mercury in the groundwater.
- The forms of mercury found in Site soils are insoluble or of low solubility (elemental mercury and metacinnabar) and, therefore, are relatively immobile.
- Shallow groundwater within the fill contains dissolved concentrations of various constituents (VOCs, SVOCs and metals) above Class IIA groundwater quality criteria, though groundwater contamination shows minimal migration horizontally and is not moving off Site to any significant extent.
- Bedrock groundwater underlying the western portion of the Site contains concentrations of VOCs, SVOCs and metals attributable to the adjacent LPH site. The currently operating groundwater extraction and treatment system on the LPH site is capturing groundwater within this area. Bedrock groundwater closest to the natural discharge point represented by the Arthur Kill exceeds human health criteria for arsenic and manganese, but does not exceed any of the aquatic saline surface water criteria.
- Sediment and low marsh soils within South Branch Creek and sediment within the Northern Off-Site Ditch are contaminated with mercury and other constituents

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above comparative criteria, especially in the near-facility areas. The most likely source of these elevated concentrations is attributable to historic overland flow from impacted areas of the Site and is not considered an ongoing source.

- Biological specimens (i.e., fish and crabs) collected in South Branch Creek contain elevated concentrations of mercury and other constituents compared with those collected in nearby areas.

2.8 Areas and Volumes of Media

The areas and volumes of contaminated media for use in evaluating remedial alternatives have been estimated based upon the site characterization as described in the preceding sections. As described above, Site soils, groundwater, and South Branch Creek sediments contain concentrations of various constituents above applicable or comparative criteria. In addition, to implement a soils remedy at the Site, various existing buildings and structures, some of which are contaminated with elemental mercury, would need to be demolished and the resulting demolition debris managed. The identification of areas and volumes of these media (i.e., soil, groundwater, sediment, and building debris) to be used in the evaluation of the remedial alternatives were calculated as described further below.

2.8.1 Soil

2.8.1.1 Fill, Tidal Marsh Deposits, and Glacial Till Site-Wide

As described in Section 2.3.1 and shown on Figure 2-5, there are site-wide occurrences of various constituents with concentrations above NRDCSRS within the overburden soils (i.e., anthropogenic fill, tidal marsh deposits, and glacial till) on Site. Areas and volumes of contaminated soil were calculated as follows:

- Based on soil sampling results presented in the RI and summarized in Section 2.3.1, the anthropogenic fill is assumed to be contaminated with various constituents above NRDCSRS throughout the Site, and there is no exposure or risk-based differentiation for distinguishing portions of the fill. The volume of soil represented by the anthropogenic fill layer was calculated in the following manner:
    - o Existing grade and top of the tidal marsh deposits topography, as presented in the RI, were used to create two separate three-dimensional surfaces using AutoCAD, which represent the upper and lower vertical boundaries of the anthropogenic fill.

- These surfaces were bounded laterally by the LCP property boundary along the northern, western, and southern sides of the Site and the limits of the low marsh soils along South Branch Creek along the eastern side of the Site.
- An automated feature in AutoCAD was then used to generate a "volume surface". Volume surface is a term of art in AutoCAD and simply represents the three dimensional volume represented between two limiting elevation surfaces. In this manner, the volume of anthropogenic fill (volume between the top of the fill and top of the tidal marsh deposits) and the volume of contaminated tidal marsh deposits and glacial till (volume between the top of the tidal marsh deposits and the maximum soil contamination depth surface) may be calculated.
- As mentioned in Section 2.1, a closed RCRA Unit is located to the east of the former chlor-alkali cell buildings. The soil bounded between the existing grade and top of tidal marsh deposit surfaces within this area was not included in the "volume surface" and associated volume calculated by AutoCAD for the anthropogenic fill.

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- In various areas of the Site, soil contamination has been observed below the anthropogenic fill layer, within the tidal marsh and glacial till deposits. The volume of soil contaminated with various constituents above the NRDCSRS below the anthropogenic fill layer was calculated in the following manner:
  - The RI soil boring database was queried to determine the maximum depth at which there was an exceedance of the NRDCSRS for any constituent at any soil sample location. These soil boring locations are shown on Figure 2-5.
  - The locations and maximum depths of NRDCSRS exceedances were used to create a three-dimensional surface using AutoCAD which represents the bottom limit of the Site soil contamination. This surface was bounded by the LCP property boundary along the northern, western, and southern sides of the Site and the limits of the low marsh soils along South Branch Creek along the eastern side of the Site. Depths of soil contamination in areas between borings with constituents above the NRDCSRS were calculated via AutoCAD interpolation methods. In areas along the property boundary, the depth of contamination was assumed to be held constant from the soil boring where a constituent above NRDCSRS was indentified to the property boundary. This surface includes the area of soil below the closed RCRA unit.

- An automated feature in AutoCAD was then used to generate a "volume surface" between the top of the tidal marsh deposits and the maximum soil contamination depth surface. This "volume surface" is a three-dimensional surface that represents the contaminated soil thickness below the anthropogenic fill on Site. As part of the "volume surface" creation feature, AutoCAD calculates the volume of this surface, which represents the volume of contaminated soil below the anthropogenic fill.

- The volume of soil within the area of the closed RCRA Unit was calculated similar to that described above for the anthropogenic fill, except the calculation was performed within the horizontal limits of the closed RCRA Unit.

Details on theses "volume surface" calculations as well as visual representation of contaminated soil thicknesses and associated volumes are attached in Appendix B. The total area and volumes of impacted soil from the above calculations are as follows (all values rounded):

- Total Area: 21.9 acres (Ac)
- Anthropogenic Fill Volume: 303,600 cubic yards (CY) in place
- Tidal Marsh Deposits and Glacial Till: 31,800 CY in place
- Closed RCRA Unit: 47,400 CY in place

2.8.1.2 Visible Elemental Mercury

One of the considerations in an FS is to evaluate means to address the preference under the Superfund Amendments and Reauthorization Act (SARA) given to remedial actions that employ treatment technologies that reduce the volume, toxicity, or mobility of hazardous substances and contaminants, and the expectations in the NCP regarding the preference for treatment of principal threat waste, wherever practical (40 CFR 300.430(a)(iii)). To address this preference under SARA and the NCP necessitates an evaluation of the areas and/or volumes of media that may be amenable to treatment technologies. In the case of the LCP Site, this evaluation is tempered by the presence of both anthropogenic fill and former operations-related contamination. Specifically, as discussed above in Sections 2.2 and 2.7.1.1, the Site is underlain by a sizable anthropogenic fill layer of approximately 300,000 CY over nearly 22 acres which contains various constituents above NRDCSRS, and which contribute to Site-related risks. While the anthropogenic fill is considered in the remedy selection process, typically treatment-based alternatives are not selected because of the variability and scale of historic fill. Under the assumption that at the LCP Site such an outcome related to the anthropogenic/historic fill is possible as well, then an alternative basis for estimating the

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volume and/or area of contaminated media that could be the subject of a treatment-based or other remedial action was considered, and for the LCP Site mercury, in particular the visible elemental mercury that as previously noted is considered here to be principal threat waste, provides this alternative basis.

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As described above, mercury is the principal contaminant of concern at the Site and is related to the Site's former chlor-alkali operations. In addition, mercury is also considered a persistent, bioaccumulative, and toxic substance which does not readily degrade in the environment. Based on the mercury speciation results presented in the RI, during the development of the *Human Health Risk Assessment*, it was assumed that elemental mercury comprised approximately 10% of the measured soil mercury concentration, with metacinnabar comprising the other roughly 90%. However, due to the presence of visible elemental mercury, analytical testing to determine a concentration of mercury was not possible; therefore, soil-based mercury concentrations (i.e., mg mercury per kg soil) cannot be calculated to reflect the occurrence of visible elemental mercury. This visible elemental mercury has the potential to represent a meaningful fraction of the total mass of mercury present in the Site soils (i.e. be present in a "significant" concentration in soils, as the NCP indicates could be characterized as principal threat waste).

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While risk assessment calculations for visible elemental mercury are not possible given analytical limitations in the measurements of actual mercury soil concentrations in areas where visible elemental mercury is present, the risk assessment assumed that these areas of visible elemental mercury represent areas of unacceptable human health and ecological risks through both direct contact and inhalation exposure. The potential mass, unacceptable risk assumption, characterization as principal threat waste, and relationship of visible mercury to former Site operations, make areas of visible mercury a reasonable candidate for evaluation in the FS of treatment-based or other alternatives, to address the preferences expressed in SARA and the expectations in the NCP, and, therefore, a separate volume calculation was performed to estimate the quantity of soil that could contain visible, elemental mercury.

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The areas of visible elemental mercury in soil at the LCP site are shown Figure 2-5, and the area and volume of this soil was calculated as follows:

- The area and volume of soil containing visible elemental mercury was estimated based on locations shown on Figure 2-5 and the maximum depth to which visible elemental mercury was observed at these locations. In areas where mercury was detected at depth, but not at the surface, the soil located above where mercury was visible was assumed to also contain visible mercury.

- As noted previously, there does not appear to have been substantial downward migration of visible mercury. In addition, a review of the mapping of the occurrence of visible mercury similarly suggests that a preponderance of the mass would exist in the more shallow soils. Further, the subsurface at the site contains numerous piles from building foundations in the area of the visible mercury. As a consequence, remediation in shallow soils would typically be more implementable than at greater depths even apart from the normal complications of increased depth in remediation (safety, slope stability, dewatering). Therefore, depth interval volume calculations were performed (see Appendix B for details) to assess the possibility of considering a subset volume of the soil containing visible mercury in the evaluation of alternatives. The depth interval calculations indicate that up to 77% of the visible mercury is contained in the upper six feet of soil – a meaningful fraction. Therefore, the volume of visible elemental mercury was calculated for two depth intervals, as follows:
    - Partial Depth (0 – 6 ft deep); and
    - Full Depth (0 – 17 ft deep), with the maximum depth based on the deepest location where visible mercury was noted.
- The volume calculations were performed by assigning polygons to the various areas and depth intervals represented by the sampling locations where visible mercury was evidenced.
- An adjustment factor of 10% was added to calculated soil volume to account for sloping of excavations so that excavation-based alternatives could also be appropriately evaluated.

Details of the volume calculation for soil containing visible elemental mercury are provided in Appendix B. The areas and volumes of this soil from these calculation are as follows (all values rounded):

- Area: 90,000 square feet (SF)
- Partial Depth (0 – 6 ft): 18,100 CY in place
- Full Depth (0 – 17 ft): 23,600 CY in place

2.8.2 Groundwater

For remedial alternatives which would involve management of overburden groundwater from the LCP site, a groundwater flow rate within the boundaries of the LCP site, as well as from areas outside of the Site which would flow toward a collection system were calculated assuming the following:

- Infiltration Rate:

  - Typical without a low permeability cap: 16 in/yr
  - Typical for a low permeability cap: 0.5 in/yr
- Infiltration Area:
  - Area within the LCP site property limit, including the portion of South Branch Creek above the petroleum pipe bridge culvert: 24.2 Ac
  - Area within the LCP site property limit, up to western edge of South Branch Creek: 22.2 Ac
  - Area outside of the LCP site property limit where shallow groundwater could flow into the LCP site: 1.4 Ac

Details on the calculations of the overburden groundwater flow rate that could be managed for alternatives that collect and treat groundwater are provided in Appendix B. The range of flow rates estimated from these calculations is as follows:

- With a low-permeability cap over the entire property: 1.6 gallons per minute (gpm)
- Without a low permeability cap and for the range of possible areas (22.2 acres to 25.6 acres): 19.4 – 21.1 gpm

Volumetric flow rate calculations were not performed for the bedrock water bearing zone, as the bedrock groundwater is already being captured by the existing, adjacent LPH groundwater remediation system, and this zone is not impacted by the LCP Site.

2.8.3 Sediment

As shown on Figure 2-6, the South Branch Creek sediments and the low marsh soils along the banks of South Branch Creek, as well as the Northern Ditch sediments, contain concentrations of various constituents which exceed the relevant and comparative criteria. Areas and volumes of material were calculated separately for upstream and downstream of the petroleum pipe bridge culvert across South Branch Creek. The basis for the volume of South Branch Creek sediments are estimates of depth based on sample depths from the RI, and the lateral extent of the sediments in the Creek and in the adjacent low marsh soils (i.e., above the Creek bed). For the Northern Ditch sediments, an average of the sediment measurement thicknesses presented in the RI was used. The estimates are as follows:

- Sediment\Soil Removal Depth:
  - South Branch Creek Sediment: 2.5 feet
  - Low Marsh Soils: 1 foot

- Northern Ditch Sediment: Variable based on measured sediment thickness, average of 2.2 feet.

- South Branch Creek and Low Marsh Soil Area
  - Upstream of Culvert: 50,000 square feet (SF)
  - Downstream of Culvert: 43,600 SF
- Northern Ditch Area
  - Marsh Area: 14,400 SF
  - Total Ditch Area: 24,300 SF

Details on the calculations of the volume of sediment and low marsh soil are attached in Appendix B. The estimated volume of sediments/soils from the above calculation is as follows:

- Upstream Section of South Branch Creek: 2,600 CY
- Downstream Section of South Branch Creek; 2,100 CY
- Northern Ditch: 2,000 CY

2.8.4 Building Debris

As shown on Figure 2-1, various buildings and structures remain on the LCP property. The buildings are in a state of disrepair, and in the case of the former mercury cell buildings, they are unsafe to enter. There is evidence that the some of the porous building debris contains free elemental mercury. As a result, alternatives are considered in the FS that would demolish the buildings and other structures. The structures are principally constructed of masonry. Other miscellaneous building materials represent a relatively small proportion of the overall mass of the buildings; however, there are various tanks and piping materials external to the buildings.

As a starting point in the total building debris estimate, the volume of masonry building debris which would result from the demolition of existing site buildings and structures was calculated using three different estimation methods and the results compared to generate a final estimate. The comparison was developed using four of the largest structures on Site, the former cell buildings (Buildings 230 and 240) and the cooling towers (Buildings 234 and 309). These structures were selected as they are constructed with a sizable amount of concrete, primarily in their foundation slabs and block walls. The three estimating methods used to calculate the amount of masonry building debris are as follows:

- RSMeans: A building demolition debris quantity estimation method detailed in *Environmental Remediation Estimating Methods, 2nd Edition*, published by RSMeans, involves applying a volume factor to a measured building volume to estimate the resulting demolition debris quantity. This volume factor takes into account the type of building construction (concrete, steel framed, etc.). Using an estimated combined building interior volume of 3,102,000 cubic feet for the cell buildings and cooling towers, the resulting building demolition debris based on a volume factor of 0.5, representative of buildings of concrete construction, is 57,000 CY (109,000 tons assuming 1.9 tons/cy for concrete debris).
- Data from the LPH Site Building Demolition: Data obtained by LPH on the estimated volume of masonry debris generated during the demolition of the former buildings and structures on the adjacent ISP Linden Site were used to estimate a range of volume factors. The volume factors ranged from 0.08 to 0.26, which results in a building demolition debris volume of 9,000 to 30,000 CY (17,000 to 57,000 tons) for the cell buildings and cooling towers.
- EPA: Data contained within the EPA document *Estimating 2003 Building-Related Construction and Demolition Material Amounts* allows for assigning a mass of building debris per square foot of building area demolished. Based on the data from a non-residential demolition job site survey of construction and demolition materials, an average of 158 pounds of debris are generated per square foot of commercial building demolished (with a maximum of 360 lbs/sf generated). Using these factors and the foot prints of the cell buildings and cooling towers, a building demolition debris mass of 4,200 to 9,600 tons is calculated. These quantities correspond to a volume factor range of 0.02 to 0.04.

The median value from these various methods of calculation is a volume factor of 0.08 and the mean is 0.18. For the purpose of this feasibility study, a mid-range volume factor of 0.15 was selected.

Using the volume factor of 0.15, a total debris volume can be calculated based on the interior volumes of the existing site structures and buildings. However, as noted above, various tanks, piping, and smaller non-masonry structures exist on the site. A factor of 25 percent was added to the building volume to account for this other material. Details of the calculation of total debris volume are attached in Appendix B. The estimated total volume of building debris from demolition of existing Site buildings and structures is 32,000 CY (61,000 tons).

3 REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS

3.1 Remedial Action Objectives

3.1.1 General

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Remedial action objectives (RAOs) are medium-specific goals to protect human health and the environment. Remedial Alternatives are developed to meet the RAOs. The process of identifying the RAOs follows the identification of affected media and contaminant characteristics; evaluation of exposure pathways, contaminant migration pathways and exposure limits to receptors; and the evaluation of contaminant concentrations that would result in unacceptable exposure. The RAOs are based on regulatory requirements and risk-based evaluations, which may apply to the various remedial activities being considered for the Site. This section of the FS reviews the affected media and contaminants that are required to be remediated. This information is combined with Federal, State and local regulations, presented in Section 4, that may affect remedial actions, to form a basis for evaluating how the alternatives meet the RAOs.

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Further, PRGs are presented in Section 4.2 and are based on Federal or State promulgated ARARs and risk-based levels, with consideration also given to background concentrations and other guidelines. These PRGs are used as a benchmark in the technology screening, alternative development and screening, and detailed evaluation of alternatives presented in the subsequent sections of this FS report.

3.1.2 Identification of RAOs

As an aid in identifying the RAOs, the following is a summary of site contaminants and relevant potential risk levels by medium:

Soils: Soil impacts predominate in the anthropogenic fill, and are also present but to a lesser extent in the underlying tidal marsh deposits and glacial till. Constituents present in soil that are related to former chlor-alkali Site operations include mercury, polychlorinated naphthalenes, hexachlorobenzene, PCDFs, and PCBs. Constituents associated with the anthropogenic fill include arsenic, lead, PCDDs, PAHs, and BETX. Chlorobenzene, and arsenic may also be attributable to sources adjacent to the LCP Site. These various constituents are present above PRGs. In addition, the baseline risk assessment indicated excess potential risk,

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principally from the presence of visible elemental mercury (not quantified but assumed to be unacceptable).

Groundwater : Groundwater impacts are evident in the overburden water-bearing zone to a limited extent from mercury (detected above groundwater quality standards in only two wells) but not from other chlor-alkali Site-operations related constituents, and also from various non-site-operations related constituents including arsenic, other metals, and various VOCs (e.g., benzene) and SVOCs. In the overburden water-bearing zone these constituents are found above PRGs, and the baseline risk assessment indicates potential excess cancer and non-cancer risks above benchmarks from consumption of groundwater. As described in Section 2.3.3, based on bedrock groundwater quality by comparison to the Class IIIB groundwater quality criteria at N.J.A.C. 7:9C-1.7(f), the bedrock water-bearing zone is generally not impacted from the site, but is impacted from the adjacent LPH site.

Sediments: Mercury is found above PRGs in the sediments of South Branch Creek and the Northern Off-Site Ditch. Other constituents above PRGs, ecological benchmarks, or reference levels in the sediments of South Branch Creek and the Northern Off-Site ditch include arsenic, PAHs, PCBs, and chlorinated benzenes. The baseline ecological risk assessment indicates the principal potential excess risk exists for benthic macroinvertibrates within South Branch Creek. In addition, the risk assessment could not quantitatively assess potential risk from visible elemental mercury; however, the presence of visible mercury is assumed to present an unacceptable risk to current and future terrestrial wildlife receptors.

Surface Water: In general surface water impacts were not evident except to the extent that sediment becomes suspended in surface water.

Based on the above, the RAOs that will be used to guide the development and evaluation of remedial alternatives and selection of a remedy for the LCP Site are as follows:

- Prevent or minimize potential current and future human and wildlife exposures - including ingestion and dermal contact with soils and groundwater - that present a significant risk whether from site-operations-related or non-site-operations-related constituents.
- Minimize migration of contaminated groundwater, and to the extent practicable, remediate to applicable standards.

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Deleted: and which are also based on contaminant-specific criteria applicable to the Site. The conclusions from the remedial investigation work are the primary basis for development of the RAOs, as presented in the RI and the human health and ecological risk assessments, and summarized in Section 2. Specifically, the conclusions relevant to development of the RAOs are as follows:¶
While exposure at the Site is currently limited because of the absence of operations, and fencing that restricts access, nonetheless the potential exposure pathway for soils and associated soil vapors is considered complete. The largest contributors to potential risk for the soil pathways are ingestion of inorganic mercury and inhalation of elemental mercury.¶
<#>Although potential risk was not quantified for visible mercury, potential exposure to areas containing visible elemental mercury is assumed to present unacceptable risks.¶
<#>While the shallow groundwater beneath the site is not suitable for potable use, the groundwater is classified by New Jersey as IIA. Additionally, direct contact with groundwater is a potentially complete pathway. ¶
<#>The principal area of ecological concern on site is the sediment in South Branch Creek, in particular the potential risks to benthic invertebrates within the sediment.¶

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- Remediate sediment in South Branch Creek, Northern Off-Site Ditch, and associated wetlands to levels protective of biota.
- Prevent or minimize human exposure to contaminated building materials and physical hazards that may result in potentially unacceptable risk.

3.2 General Response Actions

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¶
<#>Various constituents are found in concentrations above the NRDCSRS Site-wide as a result of the presence of anthropogenic fill.¶
<#>While groundwater is classified as IIA, it could not actually be used as a potable supply because of other applicable regulations.¶
<#>Mercury is present principally in low solubility (elemental) and insoluble (mercuric sulfide) forms and is, therefore, largely immobile under existing conditions. ¶

General response actions are broad categories of remedial response that may meet the remedial action objectives and provide technologies applicable to site-specific characteristics. The general response actions that were reviewed for their applicability to the LCP Site are as follows:

- No action
- Limited Action / Institutional Controls
- Containment
- In-situ Treatment
- Ex-situ Treatment
- Collection / Discharge
- Removal
- Disposal

The applicability of each of these general response actions to the LCP Site are described below.

3.2.1 No Action

No action would not include any future activity on the site (e.g., use restrictions). No action is typically retained as a baseline for comparison with other alternatives and is retained as such for this FS.

3.2.2 Limited Action/Institutional Controls

The limited action general response action would include institutional controls (e.g., deed notice, classification exception area) that would be a mechanism for implementation of various restrictions on the Site (e.g., potential future use of groundwater). Institutional controls are retained in this FS because they can be a component of many alternatives.

3.2.3 Containment

The purpose of the containment general response action is to isolate Site-related constituents from the surrounding environment. Technologies that could be considered under this general response action include capping, subsurface barriers such as cutoff walls and horizontal barriers (e.g., liner systems). The containment general response action is applicable to the Site soil, sediment, and groundwater and, therefore, is retained for further analysis in this FS.

3.2.4 In-Situ or Ex-Situ Treatment

The general response action of treatment, whether in-situ or ex-situ, typically involves the application of any number of physical, chemical, or biological treatment methods for removal of Site-related constituents from groundwater, soils or sediments. The primary constituent of interest in soils and sediments, mercury, has been the subject of various treatment evaluations (solidification/stabilization, amalgamation, thermal treatment) and more specifically, the land disposal restriction for high-mercury hazardous waste requires the use of thermal treatment. Additionally, other constituents present in the soil and sediment are amenable to various treatment methods (e.g., solidification/stabilization of metals). Groundwater treatment is a common response action where groundwater is collected, with a number of proven technologies available for various constituents. Therefore, this general response action is retained for further analysis in this FS.

3.2.5 Collection/Discharge

The general response action of collection/discharge, involves the means by which groundwater is collected and following treatment is released to the environment in accordance with relevant treatment standards. Collection of groundwater may be via proven technology such as wells or drains. Typical discharge options for groundwater include reinjection, discharge to surface water, or discharge to a publicly owned treatment works (POTW). Discharge is a necessary component of ex-situ treatment of groundwater, and, therefore, this general response action is also retained for further analysis in this FS.

3.2.6 Removal

The general response of removal typically involves active management of contaminated media, such as excavation of soils. The removal general response would meet remedial action objectives, for example, by excavating the contaminated Site soils or sediments and then treating them and/or managing them on-site or off-site. This general response action could control potential exposure, and therefore, is retained for further analysis in this FS.

3.2.7 Disposal

The general response action of disposal involves the means by which contaminated materials (soils, sediments, treatment process generated wastes) are managed in accordance with relevant treatment standards. For example, disposal for soil or treatment residuals may include landfilling at a permitted facility. Disposal is a component of removal technologies, and to some extent ex-situ treatment technologies, and therefore, is retained for further analysis in this FS.

Section 4.0 identifies various technologies that are applicable to the retained general response actions, and screens these technologies further for development of remedial action alternatives that will address the remedial action objectives for the site.

4 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

4.1 Applicable or Relevant and Appropriate Requirements

This section outlines Federal and/or State environmental regulations and laws which can be used for evaluation of the proposed remedial alternatives for the LCP site. Such requirements are typically referred to as applicable or relevant and appropriate requirements (ARARs). The ARARs may be applicable to the constituent(s) of interest, location of the remedial action, or the type of remedial action. Both Federal and State environmental regulations and laws are considered. The Federal and State ARARs presented in this section are then used subsequently for screening and evaluating remedial alternatives, the permitting requirements for the alternatives, and whether there may be means to expedite permitting for the alternatives.

"Applicable" requirements are standards and requirements promulgated under Federal and/or State environmental laws that specifically address a constituent of concern, remedial action or location of a site.

"Relevant and Appropriate" requirements are standards and requirements promulgated under Federal and/or State environmental laws that, while not directly applicable, may be suitable to address a constituent of concern, remedial action or location of a site.

"To be Considered" (TBC) requirements are local ordinances, unpromulgated criteria, advisories, or guidance that do not meet the definition of ARARs but that may assist in the development of remedial objectives or cleanup criteria, or evaluation of alternatives, particularly where ARARs may not address all relevant site risks.

ARARs fall into three general categories, which are determined on the basis of how they are applied at a site. These categories are as follows:

- Chemical-specific: These ARARs typically define concentration-based limits for specific constituents in an environmental medium. An example of a chemical-specific ARAR is a groundwater quality standard.
- Location-specific: These ARARs set restrictions on remedial activities at a site due to its proximity to specific natural or man-made features. An example of a

location-specific ARAR would be wetlands regulations, assuming a portion of a remedial action were performed in a regulated wetland.

- Action-specific: These ARARs set controls and restrictions on the remedial action to be used at the site. Each remedial action will be governed by appropriate action-specific ARARs that will specify performance standards for the remedial action. A NJPDES permit for discharge to surface water is an example of an action-specific ARAR, which would apply to an action such as discharge of groundwater to the Arthur Kill following ex-situ treatment.

The chemical, location, and action-specific ARARs potentially applicable to the LCP Site are presented in Table 4-1. TBCs that may be potentially applicable are also noted in Table 4-1. While the remedial alternatives for the site are to be developed to meet the remedial action objectives presented in Section 3.1, and as such pertain specifically to addressing contamination found at the LCP Site, implementation of a remedial alternative may have other environmental or permitting considerations. Therefore, the ARARs represent a range of regulatory jurisdiction pertaining to the following broad categories: air, groundwater, sediment, surface water, soil, wetlands and coastal zones, hazardous waste, and fish and wildlife. Compliance with ARARs is part of the evaluation criteria used in the screening process for the detailed analysis of the remedial alternatives presented in Section 7.

4.2 Preliminary Remediation Goals

For each of the contaminants of potential concern (COPCs) identified in Section 2.6, Preliminary Remediation Goals (PRGs) have been established, and are summarized in Table 4-2. These PRGs are based on Federal and State regulations and guidance. More specifically, PRGs by medium have been established as described below.

4.2.1 Groundwater

Both Federal and State chemical-specific ARARs have been identified for groundwater, as discussed previously in Section 4.1. New Jersey groundwater quality standards are considered to be applicable to the remediation of groundwater contamination at the LCP Site. Specifically, the New Jersey chemical-specific Class IIA groundwater quality standards apply to the overburden groundwater. Federal and State primary drinking water standards (maximum contaminant levels [MCLs]) are considered to be relevant and appropriate for consideration in the remediation of the overburden groundwater since the overburden groundwater is classified as IIA (this classification includes potable use even though the overburden groundwater could not be used for potable purposes). Similarly, the USEPA Regional Screening Levels (RSLs) for tap water are "to be considered" criteria based on the overburden groundwater classification. The PRGs for groundwater, as shown in Table 4-2, are set at the New Jersey Groundwater Quality Standards. The MCLs or RSLs would apply if a COPC did not have an applicable New Jersey Groundwater Quality Standard, or if updated toxicity information is incorporated in an RSL but is not yet reflected in the standard (e.g., naphthalene).

The bedrock groundwater has been reclassified as IIIB, saline, and therefore, neither Class IIA standards nor MCLs would apply. Published numerical water quality standards are not available for Class IIIB aquifers, and a means to develop numeric standards has not yet been developed by the NJDEP. In addition, as discussed in detail in Section 2.3.3, the distribution of groundwater quality impacts (illustrated by chlorobenzene and soluble mercury) is indicative of impacts associated with the adjacent LPH site and is not associated with LCP. Chlorobenzene is associated with the adjacent LPH site, as is more soluble mercury. The impacted groundwater from the adjacent LPH site is captured by a groundwater extraction system. To the extent there is a divide in the bedrock potentiometric surface on the LCP Site and bedrock groundwater discharges to the adjacent Arthur Kill, down-gradient bedrock water quality can be compared to surface water quality standards (N.J.A.C. 7:9B) to assess the potential for impact, although the surface water quality standards are not groundwater PRGs per se. As noted in Section 2.3.3, the farthest down-gradient wells closest to surface water, namely MW-6D, MW-21D and MW-25D, have concentrations of only arsenic (MW-25D, 8.7 ug/l) and manganese (MW-6D, MW-21D and MW-25D at 2240, 4250 and 3820 ug/l, respectively) above surface water quality standards. These concentrations are above human health standards only and there are no exceedances of the aquatic standards for arsenic, and manganese does not have an aquatic standard. These constituents are not associated with historic operations, and may also be naturally occurring (manganese) or associated with other sources or anthropogenic fill (arsenic) on the Site.

4.2.2 Soils

The only applicable ARAR for soils is the NJDEP Soil Remediation Standards (N.J.A.C.7:26D). The NJ standards provide chemical-specific ARARs for direct contact exposure scenarios for soils at the site. The relevant standards are the non-residential direct contact standards, as the site is an industrial use and is zoned accordingly. These standards are summarized in Table 4-2. The USEPA RSLs also provide guidance values for Industrial Soil, and are also shown on Table 4-2. The NJ regulations also provide for development of impact to groundwater standards. However, the impact to groundwater soil standards are not included in the development of PRGs because of the presence of

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Deleted: as well as default guidance values based on use of the soil-water partition equation. The default guidance values are shown in Table 4-2. In addition, the USEPA RSLs for Protection of Groundwater ("to be considered" criteria) have been included as additional information. ¶
¶
The impact to groundwater guidance values are largely irrelevant given that

anthropogenic fill (i.e., by default a NJ Classification Exception Area (CEA) is established for an indeterminate period of time for a historic fill site as a part of the presumptive remedy), because groundwater was investigated separately in the RI thereby obviating the need for predictive remediation goals, and because the fill that stays on the Site will be designated as a solid waste management unit to which groundwater standards would not apply within/below the unit.

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Deleted: the impact to groundwater soil standards are provided for information, but are not used in selecting PRGs. The PRGs are based on the NJDEP non-residential standards, or where a standard does not exist, the industrial soil RSLs have been selected.

4.2.3 Sediments

For the purpose of this FS, sediments include both surficial sediments in South Branch Creek, as well as low marsh soils to the extent not otherwise controlled by a soils remedial component. Applicable ARARs for sediments do not exist. Rather, the only available sediments criteria which can be applied to generate PRGs are the NJDEP Ecological Screening Criteria, and in particular, the Effects Range – Low (ER-L) and Effects Range – Median (ER-M) values. The relevant numeric criteria are for saline waters, and are shown in Table 4-2. The NJDEP criteria are for screening purposes only. In addition, the Arthur Kill is regionally contaminated from a variety of contributions, and if South Branch Creek and the Northern Ditch are remediated to an ecological benchmark, recontamination could occur from tidal exchange or storm tides from the Arthur Kill. As such, it is anticipated that PRGs for sediments will be re-evaluated during the remedial design phase and may be based on available regional data to establish an Arthur Kill "background" concentrations for use as a cleanup level.

4.2.4 Surface Water

PRGs for surface water are not presented in Table 4-2, and have not been developed for the LCP Site. As previously described in Section 2.6 for the Site COPCs, contaminants are not present in surface water, or if present are found principally as a consequence of the presence of sediment in the water column. As a result, there is not a site-specific need for PRGs for surface water.

5 TECHNOLOGY IDENTIFICATION AND SCREENING

As described in Section 3.2, the following general response actions are potentially applicable to the LCP site:

- No action
- Limited Action / Institutional Controls
- Containment
- In situ Treatment
- Ex situ Treatment
- Collection / Discharge
- Removal
- Disposal

This section presents the process of identifying and screening technologies within each of the general response actions, which are potentially applicable to the remediation of the LCP Site. As noted in Section 2, mercury is the primary constituent of concern at the site, so that technology screening is preceded by a general discussion of mercury remediation considerations related to the physical properties of mercury.

5.1 MERCURY REMEDIATION CONSIDERATIONS

Remediation technologies for mercury-impacted media must consider the unique physical and chemical properties of mercury as well as regulatory factors. Mercury can be present in the environment in various forms. The properties, (i.e., water solubility and volatility) and chemical behavior of mercury vary among the different species. Mercury in the environment is most frequently encountered as elemental mercury, organic mercury compounds, mercury salts [mercury (I) (mercurous) salts or mercury (II) (mercuric) salts], and mercury oxides. Some of the various species can be inter-converted through biological and other processes occurring within the various media.

Elemental mercury is a silver white, heavy liquid at ambient temperatures. Due to its high surface tension, it forms small compact spherical droplets. The vapor pressure of elemental mercury is high (approximately 0.27 mm Hg at 100^{0}C) relative to other metals and, as such, mercury can volatilize and represent an air hazard, but it's vapor pressure is low compared to other volatile compounds (e.g., TCE at 69 mm Hg at 25^{0}C). The solubility of mercury compounds varies greatly ranging from negligible (HgS) to very soluble ($HgCl_2$, $Hg(NO_3)_2$). Some solubilities for elemental mercury and various mercury compounds are enumerated below.

Compound	Formula	Solubility, mg/L
Elemental mercury	Hg^0	0.056
Mercuric chloride	$HgCl_2$	69,000
Mercuric oxide	HgO	53
Mercurous oxide	Hg_2O	insoluble
Mercuric nitrate	$Hg(NO_3)_2$	very soluble
Mercuric ammonium chloride	$Hg(NH_2)Cl$	1,400
Mercurous nitrate	$Hg_2(NO_3)_2$	Soluble
Mercurous sulfate	Hg_2SO_4	600
Mercurous chloride	Hg_2Cl_2	2
Mercuric sulfide (meta cinnanbar)[1]	HgS	2.3×10^{-11} to 7.3×10^{-22}
Dimethyl mercury	C_2H_6Hg	1,000
Methyl mercuric chloride	CH_3HgCl	100

Note: Solubilities for temperature range of 20-25°C
[1] = Mercuric sulfide in crystalline form

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Ionized forms of mercury are strongly adsorbed by soils and sediments and are desorbed slowly. In acid soils, most mercury is adsorbed by organic matter. Therefore, the environmental mobility and the risk of exposure to mercury depend on the mercury species present and other environmental conditions (i.e., soil type, geochemistry). As previously noted in Section 2, mercury at the Site is primarily present in low mobility forms (elemental and mercuric sulfide), methyl mercury was present in only very low percentages in sediments, and mercury was generally not found in groundwater (i.e., dissolved mercury was found above the NJ groundwater quality standard in only two overburden wells).

In addition to chemical and physical considerations for mercury, remediation options must also factor in regulatory considerations, as described in Section 4. The RCRA Land Disposal Restrictions (LDRs) (40 C.F.R. 268) require treatment of hazardous wastes to Universal Treatment Standards (UTSs) prior to land disposal unless exemptions apply or variances are obtained. The LDRs for mercury impacted hazardous waste (including listed or characteristic) prohibit land disposal of hazardous waste in the high mercury subcategory (i.e., mercury concentration greater than 260 mg/kg) unless an LDR exemption or variance is sought [e.g., Equivalent Method Variance (40 CFR 268.42(b)), Treatability Variance (40 CFR 268.44), and No-Migration Petition (40 CFR 268.60)]. The regulations stipulate that hazardous waste in the high mercury subcategory must be retorted or roasted. The capacity of these treatment technologies is limited and not specifically designed to treat the volumes generated from large-scale site remediation, thus, off-site management of remediation hazardous waste in the high mercury subcategory is impractical. Based on the available information, no listed hazardous wastes are known to be present at the site with the exception of sludge contained in the closed RCRA lagoon, which is considered a K071 waste if it were to be managed (i.e., brine purification muds from mercury cell process in chlorine production, where separately prepurified brine is not used). TCLP testing performed for the RI indicates that soils have the potential to exhibit the toxicity characteristic for mercury (i.e., TCLP >0.2 mg/L mercury), in that two of the four samples tested, targeted to areas of known mercury observations, exceeded the TCLP limit for mercury, although there was not a direct correlation between total mercury concentration and TCLP result.

Effective January 1, 2013, the Mercury Export Ban Act (MEBA) also takes effect, which will prohibit the export of elemental mercury from the US. Remediation wastes such as soil contaminated with elemental mercury are exempt from the export ban provided such wastes are exported for treatment and/or disposal, and mercury is not recovered for resale or reuse. If elemental mercury is recovered from remediation wastes, then the mercury export ban applies.

The RCRA regulations and the Mercury Export Ban Act impact the potential applicability and feasibility of remedial technologies discussed herein, in particular those that include removal, ex situ treatment, and/or off-site disposal.

5.2 TECHNOLOGY IDENTIFICATION AND SCREENING

A preliminary list of candidate remediation technologies for the LCP site was presented in the *Technical Memorandum for Identification of Candidate Technologies*, prepared by Brown and Caldwell dated April 2008 and revised by HydroQual, Inc, November 2008. This preliminary list of candidate technologies was generated based on a review of available literature, published databases, vendor contacts and prior experience, and included both conventional and innovative remedial technologies. Technologies were identified for each medium of concern on the site (i.e., soil, sediment, groundwater, surface water, and building debris) and were categorized under the general response actions listed above. This preliminary work has been used as the basis for the technology identification and screening presented in this FS.

As a part of this FS, the preliminary work described above has been expanded and updated with additional information and technologies that were not identified at the time the preliminary work was originally completed. Appendix C contains general descriptions of the various technologies considered in the screening, for reference, as prepared for the 2008 preliminary screening and updated for this FS.

The identified technologies have been subjected to a two-part screening. The initial screening of the identified candidate remedial technologies is presented in Table 5-1 and is based on the technical implementability of the technologies to address the primary site COPC – mercury. Information on Table 5-1 also includes a preliminary evaluation of the potential applicability of remedial technologies to address other site COPCs. Technologies identified on Table 5-1 as "not retained for additional screening" were eliminated from the second step in the technology screening process of this FS on the basis of applicability for the remediation of mercury.

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A summary of technologies retained and eliminated during the initial step in the screening process, as presented in Table 5-1, is as follows:

Media	Retained Technologies	Eliminated Technologies
All Media	Institutional Controls	
	Caps/Cover	
	Vertical Cutoff Walls	
Soil/Sediments	Monitored Natural Attenuation	Thermal Desorption
	Excavation/Dredging	Amalgamation
	Vacuuming	Biological Treatment
	Off-Site or On-Site Landfill Disposal	Vitrification

Media	Retained Technologies	Eliminated Technologies
Soil/Sediments	Ex Situ Soil Washing	Electrokinetic Separation
	Retorting	Phytoremediation
	Solidification/Stabilization	
	Stabilization	
Soil/Sediments	Chemical Leaching	
	Soil Flushing	
Groundwater	Monitored Natural Attenuation	Permeable Reactive Barrier
	Groundwater Extraction and Treatment	Ex Situ Treatment by Ion Exchange
	Ex Situ Treatment by Chemical Precipitation / Co-precipitation	Ex Situ Treatment by Membrane Filtration
	Ex Situ Treatment by Adsorption (Activated Carbon)	Ex Situ Treatment by Air Stripping
	Ex Situ Biological Treatment	Injection to Groundwater
	Discharge to POTW	Electrokinetic Separation
	Discharge to Surface Water	Phytoremediation
		Enhanced Bioremediation
Building Debris	Off-Site or On-Site Landfill Disposal	
	Retorting	
	Solidification / Stabilization	
	Stabilization	
	Debris Washing\Vacuuming	

5.3 TECHNOLOGY SCREENING

Technologies retained from step one were then screened against the criteria of effectiveness, implementability and cost, to develop a list of practicable technologies to be used in the development of remedial alternatives for the site. The screening for retained technologies identified in Section 5.2 is summarized in Table 5-2. The three screening criteria were applied as follows:

- Effectiveness – This criterion is used to assess the ability of a technology to meet the remedial action objectives identified in Section 3. Effectiveness is measured against meaningful goals including the ability to control potential exposure pathways, and remove or reduce mass that will materially contribute to meeting the RAOs. Effectiveness also considers the nature of a technology (e.g., proven, reliable) and its applicability to site constituents and conditions.

- Implementability – This criterion is used to assess the overall feasibility of implementing a technology (i.e., availability, difficulty of implementing, schedule, and administrative considerations).
- Cost – This criterion is used as a balancing factor among technologies of similar effectiveness and implementability. Cost is evaluated on a relative scale (i.e., low, moderate, or high by comparison to other similar technologies).

After applying the above screening criteria, the remedial technologies that were not retained for consideration in developing remedial alternatives for the LCP site are listed below with the basis for their elimination:

All Media

- *Monitored Natural Attenuation:* This technology was eliminated for two principal reasons. First, the presence of anthropogenic fill throughout the site does not permit source removal as is typically a component of an MNA remedy. The anthropogenic fill also, because it exists throughout the site, does not permit a down-gradient monitoring zone to exist that would allow for attenuation and confirmation that such attenuation is occurring. Second, MNA is not applicable to the forms of mercury present in the LCP site soil and sediment because they are relatively stable (i.e., elemental mercury and cinnabar) and there are no natural processes present in the soils which would degrade or transform elemental mercury to a less toxic form of mercury.

Soil and Sediment

- *Ex Situ Treatment by On-Site Thermal Retorting:* This technology was eliminated on the basis of the extensive approval process that would be necessary to meet the substantive requirements of a TSD facility under RCRA, in particular the air permit-equivalent requirements necessary for implementation and health and safety considerations. In addition, thermal treatment facilities typically are the subject of substantial public opposition in the State of New Jersey.
- *In Situ Treatment by Soil Flushing (Chemical Leaching):* This technology was eliminated due to the difficulty for uniform distribution of flushing agents in the heterogeneous anthropogenic fill. In addition, various forms of low mobility mercury compounds found in site soils would require development of specific and potentially multiple flushing solutions.

Groundwater

- *Groundwater Collection by Extraction Wells:* This technology was eliminated due to the variable hydraulic conductivity of the overburden water-bearing zone, and the limited depth for drawdown of the water table in wells and the implications of limited drawdown on effectiveness of groundwater capture. Collection trenches are more appropriate in shallow groundwater conditions with variable fill characteristics to maintain a specified drawdown and provide continuous control along a specified alignment.

Building Debris

- *Ex situ Treatment by On-Site Thermal Retort:* Limitations on this technology applied to building debris are the same as described for ex situ treatment by on-site thermal retort for soils and sediments.
- *Solidification/Stabilization:* This technology was eliminated due to implementability considerations for crushing building demolition debris to the extent necessary to allow for the addition and reaction of solidification and stabilization chemicals admixtures (i.e., the building materials would have to be essentially reduced to aggregate size). Further, the end result of the solidification process for the materials that would be treated (i.e., masonry) would be the same matrix as currently exists. Therefore, solidification/stabilization is more costly and does not offer any additional benefits over stabilization, when stabilization is targeted to the visible elemental mercury which may be present in a portion of the building materials.

After applying the screening criteria of effectiveness, implementability and cost, the remedial technologies that were retained for consideration in developing alternatives for the LCP Site, as summarized on Table 5-2, are listed below along with a description of the basis for retaining each:

All Media

- *Institutional Controls (ICs):* ICs, including Deed Notices and Classification Exception Areas (CEAs), are likely remedial components of any remedial alternative considered technically practicable for the LCP Site. This technology is retained as it would control potential exposure pathways through use restrictions.
- *Caps/Covers:* This technology is commonly employed and is readily implemented. Caps/covers are effective for a wide-range of constituents and can

effectively control direct contact risks associated with impacted soil/sediment and limit inter-media transfer of constituents (e.g., soil to groundwater and/or sediment to surface water).

- *Treatment Cap:* Similar to the caps/covers discussed above, the treatment cap can effectively control direct contact risks. In addition, the treatment aspect of the cap would convert mercury vapor that comes in contact with a treatment reagent (e.g., sulfur), to a stable, non-volatile form such as mercuric sulfide. The treatment also would eliminate the potential for buildup of mercury vapor under the cap and provide for limited treatment of vapors from elemental mercury.
- *Vertical Cutoff Walls:* This technology is commonly employed and is readily implemented. Vertical cutoff walls are effective for a wide-range of constituents and can effectively control lateral migration of constituents.

Soil and Sediment

- *Excavation/Dredging:* This technology is commonly employed and readily implemented. Removal technologies can effectively remove source material from soil and sediment and are effective for all constituent types. Removal of soil and sediment can effectively control direct contact risks associated with impacted soil or sediment. Of note, off-site disposal options are limited for excavated material that may contain visible mercury (only one facility – USEcology/Stablex of Canada – has been identified and it is outside of the US).
- *Vacuuming:* This technology is commercially available and readily implemented. Vacuuming involves the collection of visible mercury using portable vacuuming equipment and would reduce the mass of elemental mercury in Site soils. By the nature of the technology, vacuuming would remove elemental mercury from readily accessible soil (surficial) and readily removable occurrences of elemental mercury, either prior to or during soil remedy implementation. Vacuuming would also allow for removal of visible elemental mercury from building debris.
- *Landfill Disposal:* This technology is commonly employed and readily implemented. On-site or off-site landfill disposal could effectively contain excavated/dredged materials and control direct contact risks. As noted above, for wastes containing visible mercury, off-site disposal options are limited. The RCRA LDRs would apply to hazardous wastes disposed in the US, and would require treatment to the Universal Treatment Standards (UTS) prior to land disposal, or in the case of remediation wastes to either less than 10 times the UTS or 90% treatment efficiency. The LDRs prohibit land disposal of hazardous waste

in the high mercury subcategory (concentration >260 mg/kg) unless an LDR exemption or variance is obtained.

- *Ex Situ Treatment by Soil Washing (potential addition of Chemical Leaching):* This technology is commercially available, implementable (it has been used at two mercury sites) and allows for the concentration of contaminants into a smaller volume (fines) that typically requires further treatment (stabilization) and disposal. The effectiveness of this technology is primarily dependent on soil characteristics (soil type, grain size distribution, total organic carbon). Treatability testing and potential pilot testing would be required prior to full-scale implementation. Soil washing solutions can be amended with additives (i.e., chemical leaching), if necessary to improve effectiveness.

- *Ex situ Treatment by Retorting*: This technology is commercially available and implementable, although commercial capacity is limited to small quantities of mercury containing materials. Retorting is a commonly used thermal technology for mercury recovery and is considered the EPA Best Demonstrated Available Technology (BDAT) for hazardous waste containing mercury in the high mercury subcategory (i.e., mercury concentration greater than 260 mg/kg). This technology has been retained for ex situ treatment of soils, sediments, or residuals at an off-site retorting facility. However, the limited commercial capacity would likely result in this technology being applied as an add-on to another alternative to manage some subset of wastes generated during remediation.

- *Treatment by Solidification/Stabilization*: This technology is commercially available and implementable. The effectiveness of this technology is primarily dependent on the type of S/S agent, characteristics of the media to be treated, degree of mixing, mercury species present, and remedial objectives. Given the nature of the technology, S/S could only be expected to reduce leachability and not to achieve a total concentration goal. The RI data show that mercury mobility is low under existing site conditions, and there may be little benefit in applying an S/S technology. This is in particular a consideration because S/S of mercury contaminated soils has shown mixed results relating to solubility of mercury. The solubility of mercury is affected by pH as well as conversion of mercuric sulfide to other more soluble species (e.g., mercuric oxide) during the S/S process. Various researchers have evaluated S/S options for mercury stabilization that does not result in creation of more mobile compounds or remobilization of mercury. The patented Brookhaven National Laboratories (BNL) mercury treatment process of S/S with sulfur polymer cement (actually closer to stabilization followed by microencapsulation) is an example of these evaluations, and the process has shown the ability to stabilize elemental mercury without increases in solubilization or remobilization. This process; however, is not currently a commercially available technology, nor have any others been identified that have the same level of success with conversion and stability. Treatability testing and potentially pilot testing would be necessary prior to full-scale implementation, if this technology is considered further in the detailed alternatives evaluation.

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- *In Situ Treatment by Stabilization:* This technology is similar to solidification/stabilization although it is primarily focused on the treatment of visible elemental mercury by converting elemental mercury to mercuric sulfide through the addition of a sulfur containing compound or other alternative methods to stabilize/convert visible elemental mercury into a less volatile form. For the purpose of this FS, stabilization through the addition of sulfur has been selected for evaluation, although if selected as a technology for the Site, treatability studies would be conducted during the remedy design phase to determine the most effective stabilization method. Stabilization methods, or for that matter the treatment technology, may change based on technology advancements at the time of remedy design and implementation.

  The effectiveness of the stabilization technology is primarily dependent on the degree a mixing, type and loading ratio of sulfur compound, and the presence of buried debris which could limit contact with visible elemental mercury and the sulfur compound (for in-situ application). However, the geochemistry of converting elemental mercury to mercuric sulfide has been demonstrated. Treatability testing and potentially pilot testing would be required prior to full-scale implementation to assess the practical application of the stabilization process.

Groundwater

- *Groundwater Collection Trench*: This technology is commonly employed, readily implemented, and can effectively and reliably control migration through establishing hydraulic control of site groundwater.

- *Ex Situ Groundwater Treatment and Discharge to Surface Water*: Treatment of mercury impacted groundwater is currently being conducted on the adjacent LPH site[1]. The treatment system consists of discharge to surface water following

[1] The treatment system on the adjacent LPH site is being operated as part of the remedial activities for that site. Dissolved phase mercury concentrations in the treatment system influent are being effectively removed to below the permit limits, and the data from the RI indicate lesser dissolved phase concentrations of mercury in groundwater at the LCP Site than at the LPH site. Treated effluent is discharged to the

treatment via metals precipitation, biological treatment, sand filtration, and carbon adsorption. The system is effective in removing dissolved phase mercury concentrations to within the permit limits. As previously described in Section 2, dissolved phase mercury in the bedrock water-bearing zone is attributable to the adjacent LPH site and not the LCP Site. And, in the overburden water-bearing zone, dissolved mercury is present in only two wells on the Site. Therefore, this technology, and in particular the existing treatment plant is retained for evaluation of the alternatives. All permitting requirements are in place for the existing treatment plant.

- *Discharge to POTW*: Conversion from on-site treatment and surface water discharge at the adjacent LPH site to a POTW discharge is currently being evaluated, and appears to be a feasible option that will achieve similar treatment but at reduced cost. To the extent that groundwater conditions and characteristics at the LCP site are similar to the LPH site, and in the case of mercury generally at lower levels, then a POTW discharge option also would be feasible technology for a groundwater management alternative at the LCP Site.

Building Debris

- *Landfill Disposal*: Applicability of landfill disposal for building debris is similar to that described for soils and sediments. The only additional consideration would be sizing the building debris for proper placement in a landfill, and demolition debris crushing is also available and a readily implementable technology.
- *Thermal Retorting*: Applicability of thermal retorting for building debris is similar to that described for soils and sediments, with the same sizing consideration for the debris, as noted above for landfill disposal.
- *Stabilization:* This technology is retained for potential treatment of porous building materials contaminated with visible elemental mercury. Similar to in situ treatment by stabilization for soil, discussed above, a sulfur compound could be used to convert visible elemental mercury to mercuric sulfide. Stabilization would not be applicable to the debris itself. Crushing, again, would be a component of this technology.
- *Debris Washing / Vacuuming*: This technology is commercially available and implementable. Effectiveness is primarily dependent on debris characteristics

Arthur Kill under New Jersey Pollutant Discharge Elimination System, Discharge to Surface Water (NJPDES-DSW) Permit No. NJ 0000019.

(size, porous vs. non-porous) and chemical amendments. Debris washing includes physical extraction (e.g., blasting, scarification, and high pressure steam or water sprays) and chemical extraction (e.g., acid extraction). Debris decontamination (typically power washing) is commonly performed for non-porous materials (metal), which can then be recycled. Vacuuming involves the collection of visible mercury using portable vacuuming equipment designed for managing mercury. The nature of vacuuming and the porous nature of much of the Site building debris limit this technology to the removal of elemental mercury on the surface of the building material, and as such this technology would likely be an adjunct only to other alternatives.

In summary, the retained and eliminated technologies for the LCP site are as follows:

Media	Retained Technologies	Eliminated Technologies
All Media	Institutional Controls	
	Capping	
	Treatment Cap	
	Vertical Cutoff Walls	
Soil/Sediments	Excavation/Dredging	Monitored Natural Attenuation
	Vacuuming	On-Site Thermal Retort
	On-Site or Off-Site Landfill Disposal	Chemical Leaching
	Soil Washing (with potential addition of chemical leaching)	
	Off-Site Thermal Retort	
	Solidification/Stabilization	
	Stabilization	
Groundwater	Shallow Groundwater Collection Trench	Monitored Natural Attenuation
	Ex situ Treatment (existing LPH site treatment plant) and Discharge to Surface Water	Groundwater Collection with Extraction Wells
	Discharge to POTW	
Building Debris	Off-Site Thermal Retort	On-Site Thermal Retort
	Stabilization	Solidification/Stabilization
	Debris Washing / Vacuuming	

The retained technologies are used to develop media-specific alternatives to meet the remedial action objectives presented in Section 3.1. Development and screening of the media-specific alternatives is presented in Section 6. The alternatives are screened against the criteria of effectiveness, implementability and cost to select those that are retained for detailed evaluation. The detailed evaluation of alternatives is then discussed in Section 7.

6 DEVELOPMENT AND SCREENING OF ALTERNATIVES

The technologies retained after screening, as described in Section 5, provide the basis for development of alternatives for remediation of the LCP Site. Alternatives are created by combining technologies to meet the remedial action objectives for the Site, as defined in Section 3. In addition, a "No Action" alternative is maintained throughout the feasibility study process as a baseline for comparison to other alternatives.

The retained technologies used to create alternatives may be summarized as follows:

- Institutional controls, which may be a component of any alternative.
- Containment technologies, including capping and barrier walls applicable to soil, groundwater, sediments and building materials.
- Treatment technologies, including solidification and/or stabilization, soil washing, vacuuming, and thermal retorting (limited scale) which could be applicable to soil, sediment, and building debris.
- Removal, via excavation or dredging, which would be applicable to soils and sediments.
- Building debris decontamination (washing).
- Off-site disposal, applicable to soil, sediment, and building debris.
- Groundwater treatment, ex-situ via the existing LPH site groundwater treatment plant or through a POTW.

These institutional, containment, and treatment-based technologies are then applied to the site media to create alternatives. Feasibility studies can become very complex when dealing with sites with multiple contaminated media, such as the LCP Site, because of the number of alternatives that can be combined by medium, each with potential commonality, to address all media in a single remedy. To avoid significant redundancy in the alternatives evaluation process, the initial development and screening of alternatives in this feasibility study is presented on a medium-specific basis. In this way, each retained technology presented in Section 5 can be appropriately incorporated into an alternative and properly screened while maintaining a manageable number of alternatives.

Using the above as framework, the following alternatives were developed, by medium with soil alternatives designed with an "S," groundwater alternatives designated with a "GW," sediment alternatives designated with an "SD," and building debris alternatives designated with a "B."

Media	Alternative	Description of Alternative
Soil	Alternative No. 1S	No action
	Alternative No. 2S	Cap and Institutional Controls (IC)
	Alternative No. 3S	Selective Mercury Removal, Capping, Barrier Wall and IC
	Alternative No. 4S-1	Partial Depth Selective Excavation, Capping, Off-Site Disposal and IC
	Alternative No. 4S-2	Full Depth Selective Excavation, Capping, Off-Site Disposal and IC
	Alternative No. 5S	Cap, Barrier Wall and IC
	Alternative No. 6S	Treatment Cap, Barrier Wall and IC
	Alternative No. 7S	Selective Treatment by Solidification / Stabilization, Cap and IC
	Alternative No. 8S-1	Partial Depth Selective Treatment by Stabilization, Cap and IC
	Alternative No. 8S-2	Full Depth Selective Treatment by Stabilization, Cap and IC
	Alternative No. 9S-1	Partial Depth Selective Treatment by Soil Washing, Cap and IC
	Alternative No. 9S-2	Full Depth Selective Treatment by Soil Washing, Cap and IC
	Alternative No. 10S	Excavation and Off-Site Disposal
Groundwater	Alternative No. 1GW	No action
	Alternative No. 2GW	Cap and Barrier Wall, Shallow Groundwater Collection and Treatment, Long-Term Monitoring of Deep Groundwater and IC
	Alternative No. 3GW	Shallow Groundwater Collection and Treatment, Long-Term Monitoring of Deep Groundwater and IC
Sediments	Alternative No. 1SD	No action
	Alternative No. 2SD	Erosion Controls and New Benthic Layer, and Restore/Mitigate Disturbed Wetlands

Sediments	Alternative No. 3SD	Selective Excavation of Sediments, Place On-Site, and Restore/Mitigate Disturbed Wetlands
	Alternative No. 4SD	Excavate Sediments, Place On-Site, and Restore/Mitigate Disturbed Wetlands
	Alternative No. 5SD	Excavate Sediments, Off-Site Disposal and Restore/Mitigate Disturbed Wetlands
Building Debris	Alternative No. 1B	No action
	Alternative No. 2B	Demolish, Recycle Steel, Place Other Materials On-Site
	Alternative No. 3B	Demolish, Recycle Steel, Dispose of Other Materials Off-Site
	Alternative No. 4B	Demolish, Recycle Steel, Placement of Other Materials Partially On-site and Off-Site Disposal of Remaining Debris

Each of these alternatives is described below in sufficient detail to provide a basis for screening. As described in Section 6.5, each of the medium-specific alternatives is screened against the criteria of effectiveness, implementability, and cost. The cost estimates presented for each alternative have been developed for screening purposes, and are based on generally available cost factors, cost estimating guides (e.g., Means), vendor information, remedial case studies, and experience. Where applicable, operation and maintenance components of the cost estimates are assumed over a 30-year planning horizon (i.e., long-term) and a discount rate of seven percent (USEPA guidance default value) is used for calculation of the net present worth of future costs.

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Alternatives described in the sections that follow were developed per medium, as noted above. A full, Site remedy will, therefore, be a combination of the retained alternatives presented below, one for each medium. Because alternatives for different media may contain similar components (e.g., barrier wall can be a component of both soil and groundwater remedies), the preliminary cost information presented herein for different media alternatives is not additive. Costs of alternatives presented herein are used for relative comparison with other alternatives for the same medium for screening purposes. For this reason contingencies are also not included as this stage of the process.

6.1 Soils Alternatives Development

6.1.1 Alternative No. 1S – No Action

Alternative No. 1S is intended as a baseline for comparison of other alternatives. No actions would be taken nor would any existing actions (e.g., use restrictions) be continued. There would not be any costs associated with this alternative.

6.1.2 Alternative No. 2S – Cap and Institutional Controls (IC)

Alternative No. 2S would control direct contact with soils on a Site-wide basis (i.e., contamination related to both site related operations and contamination related to anthropogenic fill) using a capping system. Due to the presence of elemental mercury, to control the inhalation exposure pathway for mercury vapor, the capping system would contain a geosynthetic membrane (i.e., vapors can migrate through unsaturated soil pore space). A variety of caps configurations could be considered for direct contact control (e.g., soil, asphalt, and concrete) and various Site reuse scenarios could become components of a cap. For example, a paved parking lot associated with redevelopment of the Site could serve as part of the cap system. However, since the specifics of redevelopment are not currently known, for the purpose of evaluating this alternative, a soil cap, including 24 inches of certified clean fill, along with geosynthetic membrane and drainage components, has been assumed since it would be representative of the various capping options, would be protective, and could be incorporated into a variety of future reuse conditions.

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The components of this alternative would be as follows:

- Site Preparation and Clearing: Site clearing would consist of removal of surface cover (e.g., vegetation) that could interfere with installation of a cap. Existing site structures (e.g., buildings, tanks, etc.) would be demolished and the debris managed as part of the Building Debris alternatives discussed subsequently. Site preparation would consist of various initial preparatory activities (soil erosion and sediment controls, temporary facilities, etc.) to facilitate remedy implementation.
- Soil Cap: The soil cap would be installed Site wide within the boundaries of the LCP Site, except for a small portion of the property to the southeast that is occupied solely by railroad tracks. This alternative consists of two potential cap layout options relative to South Branch Creek, as follows:
    - South Branch Creek Overfill: Under the alternative where the upstream section of South Branch Creek (SBC) would be filled with clean soil, the filled section of SBC would also be capped. The downstream portion of SBC would be addressed as part of the Sediment alternatives.
    - No Overfill of South Branch Creek: Under this SBC alternative, the soil cap would be installed up to the western limit of the South Branch Creek wetlands, leaving the existing South Branch Creek and the adjacent wetlands to be addressed as part of the Sediment alternatives.

  Both of these cap layout options would accommodate the sediment alternatives, as described below in Section 6.3, and selection of either option does not significantly affect the overall remedy or cost. The soil cap would consist of 24 inches of certified clean fill and would be able to support vegetation. A geosynthetic membrane to control mercury vapor and a geocomposite drainage layer for drainage control would be included. A cap of this type exceeds the cap requirements detailed in the New Jersey *Technical Requirements for Site Remediation.* The cap would be graded to provide for positive drainage. Details of the capping and grading activities would be developed during design and would be integrated with Site redevelopment, where applicable.

- Soil Erosion and Sediment Controls / Site Restoration: Standard soil erosion and sediment control practices typically implemented as part of grading and earthwork projects would be used to limit soil erosion and sediment transport during construction. Surface structures (e.g., perimeter fences) that are to remain but are removed for installation of the cap would be restored, as applicable.
- Establish Use Restrictions: An institutional control in the form of a deed notice for the area within the boundaries of the Site would be established to limit future use because contaminated materials would remain above ARARs. In addition, the deed notice would include a description of the engineering control (i.e., cap), along with details on inspection and maintenance requirements of the engineering control necessary to facilitate the long-term effectiveness of the remedy. The deed notice would also include a biennial certification, which would document that the engineering and institutional controls are continuing to perform as intended.
- Miscellaneous: Various miscellaneous activities would be required for the implementation of the soils remedy, such as the development and implementation of a health and safety plan, preparation of applicable permit equivalent applications, and construction survey work.

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, cap installation, soil erosion and sediment controls and site restoration activities. In addition, capital costs to establish the institutional controls are included based on experience. Costs for cap installation represent an average of the two possible capping limits (i.e., with or without overfill of SBC). Annual maintenance and inspection costs are included for the cap, which would include necessary maintenance and repairs (e.g., mowing, repairs to erosion related damage) as well as site inspections to support the required institutional and engineering control certifications. In addition, annual costs are included for the biennial certification for institutional/engineering controls that would remain for the Site. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 30 years. The estimated costs are summarized as follows (all values rounded):

Capital Costs	
Site Preparation and Clearing	$200,000
Capping	$5,800,000
Soil Erosion Controls/Site Restoration	$100,000
Establish Use Restrictions	$50,000
Miscellaneous (HASP, permits, survey)	$50,000
Engineering and Administration	$600,000
Total Capital Costs	**$6,800,000**
Cap Maintenance, Net Present Worth ($5,000/yr)	$60,000
Continuing Certification for Institutional Controls, Net Present Worth ($10,000/yr)	$120,000
Net Present Worth, Capital and Maintenance (7%, 30 Yrs)	**$6,980,000**

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6.1.3 Alternative No. 3S – Selective Mercury Removal, Capping, Barrier Wall and IC

Alternative No. 3S is similar to Alternative No. 2S in that it would control direct contact with soils on a site-wide basis using a capping system, but this alternative also includes two additional components (1) a low- permeability barrier wall to limit the potential for lateral migration (e.g., mercury vapor), and (2) a treatment component in the form of removal of surficial, visible elemental mercury through vacuuming.

The components of this alternative would be as follows:

- Site Preparation and Clearing: Same as Alternative No. 2S
- Visible Elemental Mercury Removal: Surficial, visible elemental mercury would be removed using vacuums designed for the collection of mercury. These vacuums contain a knock-out tank which allows for the collection of discrete beads of elemental mercury while separating out other collected items, such as soil particles. In addition, the vacuums contain a series of filters, consisting of high-efficiency particulate air (HEPA) and sulfur impregnated activated carbon filters to minimize the potential for mercury vapor emissions from the equipment during vacuuming operations. Vacuuming would be conducted prior to cap earthwork activities to collect visible mercury within the upper approximately one foot of the Site soils. Collected mercury would be placed in secure storage, likely on Site, as there are limited options for this material, particularly following implementation of the Mercury Export Ban Act. Based on the areas and volumes of media calculations presented in Section 2.7, the vacuuming is estimated to remove approximately 16% of the total estimated visible elemental mercury present at the Site.
- Soil Cap: Same as Alternative No. 2S

- Barrier Wall. To limit the potential for lateral migration, a low-permeability barrier wall would be installed along the limits of the soil cap and tie into the top of the glacial till layer (~15-foot average depth). Various alternatives are available for a barrier wall, including sheet piles, slurry wall, membrane wall, and compacted clay. A sheet pile wall (e.g., Waterloo Barrier or equal) was installed as a portion of the remediation on the adjacent LPH site, and a portion of this existing barrier wall forms the northern boundary of the LCP Site. The sheet pile wall was selected at the LPH site because of installation advantages, less impacted soil management, simplified health and safety during construction, and cost effectiveness. For the purpose of this feasibility study, the same sheet pile barrier wall is included, as representative of the options. A final decision on the type of barrier wall would be made during remedy design, and selection of an alternative type of wall would not affect the evaluation of this alternative. The LCP Site barrier wall would tie into the existing LPH site barrier wall at the northern and western edges of the LCP Site boundary. Along the northern LCP property boundary, the existing LPH barrier wall would provide containment for the LCP Site, and a new wall in this area would not be necessary.
- Soil Erosion and Sediment Controls and Site Restoration: Same as Alternative No. 2S
- Establish Use Restrictions: Same as Alternative No. 2S
- Miscellaneous: Same as Alternative No. 2S

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, visible elemental mercury removal via vacuuming, cap and barrier wall installation, soil erosion and sediment controls and site restoration activities. Costs for cap and barrier wall installation represent an average of the two possible capping limits (i.e., with or without overfill of SBC). In addition, capital costs to establish the institutional controls are included based on experience. Annual maintenance and inspection costs are included for the cap; routine maintenance is not necessary for the barrier wall. The cap maintenance and inspection activities would include necessary maintenance and repairs (e.g., mowing, repairs to erosion related damage) as well as site inspections to support the required institutional and engineering control certifications. In addition, annual costs are included for the biennial certification for institutional/engineering controls that would remain for the Site. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 30 years. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$200,000
Visible Elemental Mercury Removal (Surface Vacuuming)	$600,000
Capping and Barrier Wall	$8,400,000
Soil Erosion Controls/Site Restoration	$100,000
Establish Use Restrictions	$50,000
Miscellaneous (HASP, permits, survey)	$50,000
Engineering and Administration	$900,000
Total Capital Costs	**$10,300,000**
Cap Maintenance, Net Present Worth ($5,000/yr)	$60,000
Continuing Certification for Institutional Controls, Net Present Worth ($10,000/yr)	$120,000
Net Present Worth, Capital and Maintenance (7%, 30 Yrs)	**$10,480,000**

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6.1.4 Alternative No. 4S-1 – Partial Depth Selective Excavation, Capping, Off-Site Disposal and IC

Alternative No. 4S-1 is similar to Alternative No. 2S in that it would control direct contact with soils on a site-wide basis using a capping system. However, Alternative No. 4S-1 includes the removal of visible elemental mercury through excavation and off-site disposal. As presented in Section 2.7.1.2, a majority of the mass of visible elemental mercury is contained within shallower soils (i.e., less than 6 feet deep). The area where a majority of the elemental mercury has been observed is located under and adjacent to existing structures and buildings. Because these facilities were built on uncontrolled (from a geotechnical perspective) fill, the subsurface in this area contains numerous building piles and foundation structures. These piles and foundation structures would substantially complicate removal of soils, and the complexity would increase as the depth of the soils remedy increases. The difficulties are associated with both normal excavation considerations including slope stability and dewatering but also with potential elevated exposure to mercury vapors and the need for specialized equipment. Alternative No 4S-1 represents an option that addresses a substantial portion of the visible elemental mercury while minimizing implementability issues associated with the Site and foundation piles and structures. In addition, other COPCs would be removed from these excavation areas as they are co-located with the occurrence of visible elemental mercury.

The components of this alternative would be as follows:

- Site Preparation and Clearing: Same as Alternative No. 2S
- Excavation and Off-Site Disposal of Soil with Visible Elemental Mercury: Excavation depth would be to 6 feet below grade, based on the observed locations of visible elemental mercury as shown in the RI, resulting in removal of approximately 18,100 cubic yards of soil containing visible elemental mercury.

Excavation areas would be sloped within acceptable safety limits (i.e., OSHA limits) or appropriate side slope support would be used. As described in Section 2, of the four TCLP samples tested, two failed and would be considered hazardous waste. If this were representative of the 18,100 cubic yards of soil excavated, then 9,000 cubic yards could be hazardous waste, and would have to be managed through a retort facility because the levels of mercury would subject the soil to the land disposal restrictions. Such capacity does not exist at currently operating retort facilities. In addition, there are currently no US based disposal facilities that will accept soil with visible elemental mercury, even if non-hazardous. To date, for the preparation of this FS, only one facility, USEcology/Stablex of Canada, Inc. has been identified that would accept the excavated soil with visible elemental mercury. For the purposes of costing this alternative, therefore, it has been assumed that the soils would be disposed at the USEcology facility in Canada. Based on the areas and volumes of media calculations presented in Section 2.7, approximately 77% of the total estimated quantity of soils present at the Site with visible elemental mercury would be removed through implementation of this alternative.

- Post-Excavation Confirmatory Sampling: The post-excavation sampling component of this alternative would be designed to confirm that at the lateral limits of excavation the soils no longer exhibit the presence of visible elemental mercury. Sampling activities would involve both collection of excavation sidewall samples for visual analysis and direct observation of the excavation sidewall for the occurrence of visible elemental mercury. Excavation sidewall samples would also be tested for the presence of visible elemental mercury utilizing a headspace analysis for volatile mercury testing method. If additional visible elemental mercury is identified along the limits of the excavation side slope, soil within that area would be removed until elemental mercury is no longer observed. Post-excavation samples would be located in a manner generally consistent with the NJDEP *Technical Requirements for Site Remediation*, or other relevant technical guidance at the time the work is performed.
- Backfill: Following the completion of the post-excavation confirmatory samples, the excavation areas would be backfilled with appropriate fill (e.g., clean or a beneficial reuse material, as contaminants will remain on Site), and graded as appropriate for the installation of the soil cap.
- Soil Cap: Same as Alternative No. 2S
- Soil Erosion and Sediment Controls and Site Restoration: Same as Alternative No. 2S
- Establish Use Restrictions: Same as Alternative No. 2S

- Miscellaneous: Same as Alternative No. 2S

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, removal and off-site disposal of soil containing visible elemental mercury, post-excavation confirmatory sampling, cap installation, soil erosion and sediment controls, and site restoration activities. Costs for cap installation represent an average of the two possible capping limits (i.e., with or without overfill of SBC). In addition, capital costs to establish the institutional controls are included based on experience. Annual maintenance and inspection costs are included for the cap, which would include necessary maintenance and repairs (e.g., mowing, repairs to erosion related damage) as well as site inspections to support the required institutional and engineering control certifications. In addition, annual costs are included for the biennial certification for institutional/engineering controls that would remain for the Site. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 30 years. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$200,000
Excavation and Backfill	$1,000,000
Off-Site Disposal (USEcology, Canada)	$26,500,000
Post-Excavation Confirmatory Sampling	$25,000
Capping	$5,800,000
Soil Erosion Controls/Site Restoration	$100,000
Establish Use Restrictions	$50,000
Miscellaneous (HASP, permits, survey)	$50,000
Engineering and Administration	$700,000
Total Capital Costs	**$34,425,000**
Cap Maintenance, Net Present Worth ($5,000/yr)	$60,000
Continuing Certification for Institutional Controls, Net Present Worth ($10,000/yr)	$120,000
Net Present Worth, Capital and Maintenance (7%, 30 Yrs)	**$34,605,000**

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6.1.5 Alternative No. 4S-2 – Full Depth Selective Excavation, Capping, Off-Site Disposal and IC

Alternative 4S-2 is the same as Alternative 4S-1 except that the goal of this alternative would be removal of soils containing visible elemental mercury to the maximum depth observed at the Site, as shown in the RI.

The components of this alternative would be as follows:

- Site Preparation and Clearing: Same as Alternative No. 2S
- Excavation and Off-Site Disposal of Soil Containing Visible Elemental Mercury: This component of the remedy is the same as Alternative No. 4S-1, except that excavation would be based on the observed locations of visible elemental mercury

documented in the FS, and based on these data the maximum excavation depth is estimated at 17 feet. This would result in an estimated excavation volume of 23,600 cubic yards of soil with visible, elemental mercury. Excavation would also occur beneath the existing building footprints. The Site buildings are supported on pile foundations and numerous piles and pile caps could interfere with excavation. Consequently, this alternative would require further evaluation of the impacts of foundation structures on removal of the material to a depth of 17 feet.

- Post-Excavation Confirmatory Sampling: Post-excavation confirmatory sampling would be conducted similar to that described for Alternative No. 4S-1, with the addition of sampling in the excavation bottom to confirm the base of the excavation has also had the visible elemental mercury removed as well as along the lateral extents.
- Backfill: Same as Alternative No. 4S-1
- Soil Cap: Same as Alternative No. 2S
- Soil Erosion and Sediment Controls and Site Restoration: Same as Alternative No. 2S
- Establish Use Restrictions: Same as Alternative No. 2S
- Miscellaneous: Same as Alternative No. 2S

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, removal and off-site disposal of soil containing visible elemental mercury, post-excavation confirmatory sampling, cap installation, soil erosion controls and sediment controls, and site restoration activities. Costs for cap installation represent an average of the two possible capping limits (i.e., with or without overfill of SBC). In addition, capital costs to establish the institutional controls are included based on experience. Annual maintenance and inspection costs are included for the cap, which would include necessary maintenance and repairs (e.g., mowing, repairs to erosion related damage) as well as site inspections to support the required institutional and engineering control certifications. In addition, annual costs are included for the biennial certification for institutional/engineering controls that would remain for the Site. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 30 years. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$200,000
Excavation and Backfill	$1,300,000
Off-Site Disposal (USEcology, Canada)	$34,500,000
Post-Excavation Confirmatory Sampling	$25,000
Capping	$5,800,000
Soil Erosion Controls/Site Restoration	$100,000
Establish Use Restrictions	$50,000
Miscellaneous (HASP, permits, survey)	$50,000
Engineering and Administration	$800,000
Total Capital Costs	**$42,825,000**
Cap Maintenance, Net Present Worth ($5,000/yr)	$60,000
Continuing Certification for Institutional Controls, Net Present Worth ($10,000/yr)	$120,000
Net Present Worth, Capital and Maintenance (7%, 30 Yrs)	**$43,005,000**

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6.1.6 Alternative No. 5S – Cap, Barrier Wall and IC

Alternative No. 5S is similar to Alternative No. 3S, with the exception that it is containment-based without removal of surficial, visible elemental mercury through vacuuming. This alternative would function similarly to Alternative 3S in that it would control direct contact with soils on a Site-wide basis using a capping system, and the low-permeability barrier wall would limit the potential for lateral migration (e.g., mercury vapor).

The components of this remedy would be as follows:

- Site Clearing: Same as Alternative No. 2S
- Soil Cap: Same as Alternative Nos. 2S and 3S
- Barrier Wall: Same as Alternative No. 3S
- Soil Erosion and Sediment Controls and Site Restoration: Same as Alternative Nos. 2S and 3S
- Establish Use Restrictions: Same as Alternative Nos. 2S and 3S
- Miscellaneous: Same as Alternative Nos. 2S and 3S

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, cap and barrier wall installation, and soil erosion and sediment controls, and site restoration activities. Costs for cap and barrier wall installation represent an average of the two possible capping limits (i.e., with or without overfill of SBC). In addition, capital costs to establish the institutional controls are included based on experience. Annual maintenance and inspection costs are included for the cap; routine maintenance is not necessary for the barrier wall. The cap maintenance and inspection activities would include necessary maintenance and repairs (e.g., mowing, repairs to erosion related damage) as well as site inspections to support the required institutional and engineering control certifications. In addition, annual costs are included for the biennial certification for institutional/engineering controls that would remain for the Site. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 30 years. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$200,000
Capping and Barrier Wall	$8,400,000
Soil Erosion Controls/Site Restoration	$100,000
Establish Use Restrictions	$50,000
Miscellaneous (HASP, permits, survey)	$50,000
Engineering and Administration	$900,000
Total Capital Costs	**$9,700,000**
Cap Maintenance, Net Present Worth ($5,000/yr)	$80,000
Continuing Certification for Institutional Controls, Net Present Worth ($10,000/yr)	$150,000
Net Present Worth, Capital and Maintenance (7%, 30 Yrs)	**$9,880,000**

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6.1.7 Alternative No. 6S – Treatment Cap, Barrier Wall and IC

Alternative No. 6S is similar to Alternative No. 5S; however, in this alternative the cap would contain a treatment component. The concept behind the treatment component of the cap is the knowledge that reacting elemental mercury with a sulfur-based compound will result in the formation of cinnabar (i.e., mercuric sulfide) to some degree, dependent on a variety of conditions (Svensson, M, et al., 2005). Work conducted by Brookhaven National Laboratory (Kalb, 2008) also showed that a sulfur-based compound could be used to treat elemental mercury impacted soil. In the BNL study, treatment rods containing a sulfur-based compound were placed into elemental mercury impacted soil. Over time cinnabar formed in the vicinity of the treatment rods. It is theorized that this reaction occurs in the vapor phase between mercury vapor and sulfur. By including a sulfur-based component in the soil cap, some treatment of mercury vapor would result, and would further limit mercury vapor pathway and the potential for mercury vapor buildup below the cap.

The components of this remedy would be as follows:

- Site Preparation and Clearing: Same as Alternative No. 2S
- Treatment Cap: The treatment cap is similar to that described in Alternative Nos. 2S, 3S and 5S with the addition of a treatment layer to convert mercury vapor to cinnabar below the cap. For the purpose of costing this alternative, the treatment

component would consist of a three-inch thick layer of powdered elemental sulfur, placed underneath the geosynthetic membrane component of the cap. Treatability testing would be required prior to remedy implementation to determine the optimal sulfur-based compound to be utilized and the required treatment layer thickness to provide for a long-term reactive zone to treat mercury soil vapor which could accumulate below the cap.

- Barrier Wall: Same as Alternative Nos. 3S and 5S.
- Soil Erosion and Sediment Controls and Site Restoration: Same as Alternative Nos. 2S and 5S
- Establish Use Restrictions: Same as Alternative No. 2S
- Miscellaneous: Same as Alternative No. 2S

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, cap installation including a sulfur compound for the treatment layer, soil erosion and sediment controls, and site restoration activities. Costs for cap and barrier wall installation represent an average of the two possible capping limits (i.e., with or without overfill of SBC). In addition, capital costs to establish the institutional controls are included based on experience. Annual maintenance and inspection costs are included for the cap; routine maintenance is not necessary for the barrier wall. The cap maintenance and inspection activities would include necessary maintenance and repairs (e.g., mowing, repairs to erosion related damage) as well as site inspections to support the required institutional and engineering control certifications. In addition, annual costs are included for the biennial certification for institutional/engineering controls that would remain for the Site. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 30 years. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$200,000
Treatment Cap and Barrier Wall	$8,500,000
Soil Erosion Controls/Site Restoration	$100,000
Establish Use Restrictions	$50,000
Miscellaneous (HASP, permits, survey)	$50,000
Engineering and Administration	$900,000
Total Capital Costs	**$9,800,000**
Cap Maintenance, Net Present Worth ($5,000/yr)	$60,000
Continuing Certification for Institutional Controls, Net Present Worth ($10,000/yr)	$120,000
Net Present Worth, Capital and Maintenance (7%, 30 Yrs)	**$9,980,000**

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6.1.8 Alternative No. 7S – Selective Treatment by Solidification / Stabilization, Cap and IC

This alternative is based on Alternative No. 2S (i.e., installation of a soil cap) along with treatment of soil containing visible elemental mercury with a solidification/stabilization (S/S) method. S/S methods typically involve mixing of impacted soil with reagents to reduce the mobility of the constituents, reduce the permeability of the soil, and limit leaching of the constituents from the stabilized soil matrix. During the mixing process, constituents are physically bound or enclosed within a matrix. The most common S/S methods involve the use of Pozzolanic materials (e.g., Portland cement). In addition, other proprietary reagents or patented processes have been used, such as sulfur polymer cement.

The actual mixing process of the remedy could occur both in situ or ex situ. Ex situ methods tend to be more difficult to implement both due to the increase in impacted soil management (e.g., increased mercury vapor exposure) and also, once the impacted soil is excavated, management of the soil as a waste under the RCRA regulations is then required. Under RCRA the land disposal restrictions (i.e., LDRs) would apply to the treatment of the soils that are classified as hazardous by characteristic. For the purposes of this FS, selective treatment by S/S is assumed to be in-situ as this simplifies the overall management of the soil under RCRA. However a final determination of method, along with treatability studies would be required to identify the specific reagents and mixing protocols to solidify and stabilize the elemental mercury in the Site soils.

In addition to addressing the visible elemental mercury through treatment, this alternative would also control direct contact with soils on a site-wide basis using a capping system.

The components of this remedy would be as follows:

- Site Preparation and Clearing: Same as Alternative No. 2S
- In Situ Solidification / Stabilization: In situ solidification / stabilization would be conducted within the area of visible elemental mercury (see Figure 2-5), to the lateral extent and depth (maximum of 17 feet from the RI data) defined by such observations. Mixing would be conducted with specialized soil mixing equipment (e.g., large augers) to enhance the uniformity of soil and reagent mixing process. For costing purposes, a reagent mix of 15% cement (e.g., typical proportion of cement in concrete mixes) and 1% sulfur is assumed on a weight by weight of soil basis. Sulfur is included in the reagent mix to facilitate the formation of less mobile forms of mercury to further enhance the S/S process. In addition, soil mixing would be conducted in each sub-area (e.g., 10 foot by 10 foot grid) for a time sufficient to provide for a uniform mixture of soil and

reagent. Soil volume increase associated with the addition of the S/S reagents would be graded appropriately to facilitate the installation of the soil cap.

- Soil Cap: Same as Alternative No. 2S
- Soil Erosion and Sediment Controls and Site Restoration: Same as Alternative No. 2S
- Establish Use Restrictions: Same as Alternative No. 2S
- Miscellaneous: Same as Alternative No. 2S

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, in situ solidification / stabilization, cap installation, soil erosion and sediment controls, and site restoration activities. Costs for cap installation represent an average of the two possible capping limits (i.e., with or without overfill of SBC). In addition, capital costs to establish the institutional controls are included based on experience. Annual maintenance and inspection costs are included for the cap, which would include necessary maintenance and repairs (e.g., mowing, repairs to erosion related damage) as well as site inspections to support the required institutional and engineering control certifications. In addition, annual costs are included for the biennial certification for institutional/engineering controls that would remain for the Site. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 30 years. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$200,000
In-situ Solidification/Stabilization	$3,200,000
Capping	$5,800,000
Soil Erosion Controls/Site Restoration	$100,000
Establish Use Restrictions	$50,000
Miscellaneous (HASP, permits, survey)	$50,000
Engineering and Administration	$900,000
Total Capital Costs	**$10,300,000**
Cap Maintenance, Net Present Worth ($5,000/yr)	$60,000
Continuing Certification for Institutional Controls, Net Present Worth ($10,000/yr)	$120,000
Net Present Worth, Capital and Maintenance (7%, 30 Yrs)	**$10,480,000**

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6.1.9 Alternative No. 8S-1 – Partial Depth Selective Treatment by Stabilization, Cap and IC

Alternative No. 8S-1 is similar to Alternative No. 7S, however, stabilization would be conducted with the primary goal to convert the visible elemental mercury to mercuric sulfide, without the addition of a solidification reagent (e.g., cement). A solidification reagent would not be included due to the potential issues associated with such reagents, as discussed further in Section 6.7.3.

Various research studies have been conducted on the stabilization of elemental mercury through the formation of cinnabar (Svensson et at, Lopez et al., USDOE). These research studies have indicated that cinnabar formation is possible without application of heat (i.e., at room temperature) through mixing of elemental mercury with a sulfur-based compound. Even though both elemental mercury and cinnabar are low mobility forms of mercury, cinnabar is insoluble, does not generate mercury vapors, and is a solid at ambient temperatures as opposed to liquid. This alternative would apply stabilization with the goal of chemically controlling the inhalation exposure pathway, and forming an even lower mobility compound. As for other similar alternatives with a cap, this alternative would also control direct contact with soils on a Site-wide basis through a capping system.

As previously discussed in Section 2.7.1.2, a majority of the mass (~77%) of visible elemental mercury is contained within shallower soils (i.e., less than 6 feet deep), and this partial depth approach has been included as an alternative to address implementability issues with deeper soil remediation. Implementability would be similarly enhanced for shallow soil mixing versus deeper soil mixing that may be impeded by site features (e.g., numerous piles for building foundations). As such, Alternative 7S-1 involves the treatment of visible elemental mercury to a maximum depth of six feet.

The components of this remedy would be as follows:

- Site Preparation and Clearing: Same as Alternative No. 2S
- In Situ Stabilization: The extent of in situ stabilization of visible elemental mercury would be the same as for Alternative No. 7S, except that the depth would be limited to six feet. The other aspects of this component are similar to Alternative No. 7S; in situ treatment, use of specialized mixing equipment (e.g., augers), and mixing in a grided set of sub-areas. Research conducted on the formation of cinnabar through the mixing of elemental mercury and sulfur indicates a typical sulfur loading rate (i.e., reagent addition rate) of 50% weight sulfur per weight mercury (wt/wt mercury). As described in Section 2, it is not possible to analytically measure the amount of elemental mercury in areas where elemental mercury was observed, and this value is needed to calculate (stoichiometrically) the mass of sulfur necessary to convert the elemental mercury to cinnabar. To estimate the amount of sulfur to convert the elemental mercury to cinnabar, therefore, data from the remediation of a similar former chlor-alkai site, LCP Bridge Street, was used to calculate a representative mass of visible elemental mercury per cubic yard of soil. Mercury contaminated soils were treated at the LCP Bridge Street site through soil washing. The soil washing

physically removed and separated beads of elemental mercury. Therefore, the mass of mercury collected from the soil washing operation would be considered representative of the mass of “visible” elemental mercury. Data from the LCP Bridge Street soil washing operations indicated that the soils contained, on average, approximately 2.2 pounds of visible elemental mercury per cubic yard of soil (Parsons, 2009). Based on a typical sulfur loading rate of 50% wt/wt mercury necessary to chemically convert elemental mercury to cinnabar, this would mean that approximately 1 pound of sulfur would be required per cubic yard of soil, which is approximately 0.04% on a weight by weight soil basis. Even though a sulfur loading rate of 50% wt/wt mercury would be sufficient to convert the elemental mercury to mercuric sulfide stoichiometrically, this volume of sulfur is so small compared to the overall soil volume targeted for treatment, such that treatment may not occur due to the fact the sulfur and mercury would be unable to react (i.e., contact) with each other. For this reason, it is assumed that, for the purpose of costing this alternative, sulfur would be applied at approximately 25% wt/wt soil to provide for contact between the visible elemental mercury and sulfur. This percentage is more typical of empirical data at sites where some form of S/S technology has been applied. The actual mix percentage would have to be determined from treatability studies which would precede final design of such an alternative, if selected. In addition, as previously mentioned, treatability studies would investigate the potential for stabilization methods other than sulfur which may potentially be viable at the time treatability studies are conducted, or even potentially alternative, equivalent treatment technologies.

- Soil Cap: Same as Alternative No. 2S
- Soil Erosion and Sediment Controls and Site Restoration: Same as Alternative No. 2S
- Establish Use Restrictions: Same as Alternative No. 2S
- Miscellaneous: Same as Alternative No. 2S

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, in-situ stabilization, cap installation, soil erosion and sediment controls, and site restoration activities. Costs for cap installation represent an average of the two possible capping limits (i.e., with or without overfill of SBC). In addition, capital costs to establish the institutional controls are included based on experience. Annual maintenance and inspection costs are included for the cap, which would include necessary maintenance and repairs (e.g., mowing, repairs to erosion related damage) as well as site inspections to support the required institutional and engineering control certifications. In addition, annual costs are included for the biennial certification for institutional/engineering controls that would remain for the Site. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 30 years. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$200,000
In-situ Stabilization	$5,300,000
Capping	$5,800,000
Soil Erosion Controls/Site Restoration	$100,000
Establish Use Restrictions	$50,000
Miscellaneous (HASP, permits, survey)	$50,000
Engineering and Administration	$1,200,000
Total Capital Costs	**$12,700,000**
Cap Maintenance, Net Present Worth ($5,000/yr)	$60,000
Continuing Certification for Institutional Controls, Net Present Worth ($10,000/yr)	$120,000
Net Present Worth, Capital and Maintenance (7%, 30 Yrs)	**$12,880,000**

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6.1.10 Alternative No. 8S-2 – Full Depth Selective Treatment by Stabilization, Cap and IC

Alternative 8S-2 is the same as Alternative 8S-1 except instead of addressing a depth of six feet for treatment of soil containing visible elemental mercury, this alternative would be conducted within the area of visible elemental mercury (see Figure 2-5), to the lateral extent and depth (maximum of 17 feet from the RI data) defined by such observations.

The components of this remedy would be as follows:

- Site Preparation and Clearing: Same as Alternative No. 2S
- In Situ Stabilization: Same as Alternative No. 8S-1, except depth not limited to six feet. Stabilization would also occur beneath the existing building footprints. The Site buildings are supported on pile foundations and numerous piles and pile caps could interfere with the work. Consequently, this alternative would require further evaluation of the impacts of foundation structures on stabilization of the material to a depth of 17 feet.
- Soil Cap: Same as Alternative No. 2S
- Soil Erosion and Sediment Controls and Site Restoration: Same as Alternative No. 2S
- Establish Use Restrictions: Same as Alternative No. 2S
- Miscellaneous: Same as Alternative No. 2S

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, in-situ stabilization, cap installation, soil erosion and sediment controls, and site restoration activities. Costs for cap installation represent an average of the two possible capping limits (i.e., with or without overfill of SBC). In addition, capital costs to establish the institutional controls are included based on experience. Annual maintenance and inspection costs are included for the cap, which would include necessary maintenance and repairs (e.g., mowing, repairs to erosion related damage) as well as site inspections to support the required institutional and engineering control certifications. In addition, annual costs are included for the biennial certification for institutional/engineering controls that would remain for the Site. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 30 years. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$200,000
In-situ Stabilization	$6,800,000
Capping	$5,800,000
Soil Erosion Controls/Site Restoration	$100,000
Establish Use Restrictions	$50,000
Miscellaneous (HASP, permits, survey)	$50,000
Engineering and Administration	$1,300,000
Total Capital Costs	**$14,300,000**
Cap Maintenance, Net Present Worth ($5,000/yr)	$60,000
Continuing Certification for Institutional Controls, Net Present Worth ($10,000/yr)	$120,000
Net Present Worth, Capital and Maintenance (7%, 30 Yrs)	**$14,480,000**

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6.1.11 Alternative No. 9S-1 – Partial Depth Selective Treatment by Soil Washing, Cap and IC

Alternative No. 9S-1 is similar to Alternative 8S-1, except that soil washing is substituted as the treatment technology. As contaminants are typically adsorbed to the fines fraction of soil, the soil washing process would attempt to concentrate contamination on the fines fraction of the soil, and thereby reduce the contaminant concentration of the remaining coarse-grained fraction of the soil. In addition, soil washing has been used (e.g., LCP Bridge Street Site, Syracuse, NY) to physically separate visible elemental mercury from the soil particles. Based on experience at other sites, the washing process is not expected to result in soil that would meet unrestricted soil use criteria. For example, at the LCP Bridge Street site, the average mercury concentration in the soil prior to washing was approximately 2,200 mg/kg, and following washing the coarse-grained fraction had an average mercury concentration of approximately 640 mg/kg, well above any relevant chemical-specific ARAR. Therefore, the soil would still have to be managed as contaminated after treatment. So, the focus of the soil washing is on the elemental mercury, similar to the stabilization treatment option. However, in this case the elemental mercury would be physically removed from the soil. As for other similar alternatives with a cap, this alternative would also control direct contact with soils on a Site-wide basis through a capping system.

Soil washing is conducted as an ex-situ process. As previously described, LDRs would also apply to the treatment residuals that are generated by the soil washing process (e.g., fines, wash water). Therefore, in addition to the soil washing process, other treatment technologies, such as stabilization, would potentially be required to treat process residuals which do not meet LDRs prior to disposal.

Similar to Alternatives 4S and 8S, due to the occurrence of numerous building piles and foundations within the area of visible elemental mercury and the associated construction implementation issues, Alternative 9S-1 involves the treatment of soil to a maximum depth of six feet. Alternative 9S-2, discussed subsequently, is the full-depth alternative for the soil washing process.

The components of this remedy would be as follows:

- Site Preparation and Clearing: Same as Alternative No. 2S
- Excavation: The soil treatment depth would be to six feet below grade, as previously described for Alternative 8S-1; however, in this case soils would be excavated to this depth to be put through the ex-situ soil washing process. Excavated soils would be stockpiled on-site to await processing by soil washing. Stockpiled soils would be covered to control potential mercury vapor emissions. Other means of suppressing mercury vapor would also likely be used during soils handling, such as temporary foam cover or sequestering agents (e.g., HgX). Excavation areas would be sloped within acceptable safety limits (i.e., OSHA limits).
- Soil Washing: Soil washing of excavated soils would occur in an enclosed area where mercury vapors generated could be collected and treated, typically through sulfur impregnated vapor phase granular activated carbon. Based on the soil classifications provided in the RI, the fill soils which would predominant as the soil type to be treated, have a high proportion of fine-grained material, averaging 50% or more. Due to the high fines content of the Site soil, therefore, on the order of 50% of the excavated soils would be separated as fines by the soil washing process. As soil washing is an ex situ treatment method, RCRA LDRs would apply to the excavated soils if they are to be reused on Site, and to the extent the soils would be classified as hazardous waste. If non-hazardous, the residual fines would have to be managed as waste, but the LDRs would not apply. Again using the similar LCP Bridge Street site as a guide, following soil washing, approximately 75% of the residual fines were classified as hazardous based on

mercury TCLP extract results. As a result, the fines for the Bridge Street site were further treated by solidification/stabilization with a cement admixture. Therefore, for the purpose of evaluating this alternative, prior to reusing the washed soil for backfill of the excavation area to facilitate the installation of the soil cap, the fines fraction is assumed to be treated by an ex situ S/S process. Fines which do not meet LDR requirements following ex situ S/S would be disposed of off-site as hazardous waste. Replacement of the treated soils on the Site would also entail use of a Corrective Action Management Unit (CAMU) per 40 CFR 264.552. A CAMU is designed to facilitate remediation activities on a site, and is particularly well suited to the LCP Site because of the presence of anthropogenic fill, and the probability that complete site restoration is not practicable, as is discussed further later in this section. A CAMU requires compliance with certain containment design standards and minimum treatment standards or site-specific adjusted standards. The application of treatment by soil washing, accompanied by containment such as a cap, should represent action compatible with a CAMU designation. However, the specific requirements for such a designation would have to be confirmed during design.

- Off-Site Disposal: It is possible that even after additional S/S of the residual fines from the soil washing operation, some of the material would still be classified as hazardous and would not meet the LDRs. Using the LCP Bridge Street site again as an example, this did occur on one batch of the residual material. Following stabilization, if the residual material is still a characteristic hazardous waste for mercury (or any other site contaminants), it would be disposed off-site as hazardous waste. For the purposes of costing this remedy, it is assumed that approximately 5% of the fines generated by the soil washing process would be a characteristic hazardous waste and not meet the LDR requirements following stabilization, and would, therefore, be disposed of off-site.
- Post-Excavation Confirmatory Sampling: Same as Alternative No. 4S-1
- Backfill: Following the completion of the post-excavation confirmatory samples, the excavation areas would be backfilled with treated soil that meets LDR requirements or with other suitable fill and graded as appropriate for the installation of the soil cap.
- Soil Cap: Same as Alternative No. 2S
- Soil Erosion and Sediment Controls and Site Restoration: Same as Alternative No. 2S
- Establish Use Restrictions: Same as Alternative No. 2S
- Miscellaneous: Same as Alternative No. 2S

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, soil washing, off-site disposal of soil which cannot be utilized for site backfill, cap installation, soil erosion and sediment controls, and site restoration activities. Costs for cap installation represent an average of the two possible capping limits (i.e., with or without overfill of SBC). In addition, capital costs to establish the institutional controls are included based on experience. Annual maintenance and inspection costs are included for the cap, which would include necessary maintenance and repairs (e.g., mowing, repairs to erosion related damage) as well as site inspections to support the required institutional and engineering control certifications. In addition, annual costs are included for the biennial certification for institutional/engineering controls that would remain for the Site. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 30 years. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$200,000
Excavation and Backfill	$1,400,000
Soil Washing	$4,500,000
Off-Site Disposal (Hazardous)	$400,000
Post-Excavation Confirmatory Sampling	$25,000
Capping	$5,800,000
Soil Erosion Controls/Site Restoration	$100,000
Establish Use Restrictions	$50,000
Miscellaneous (HASP, permits, survey)	$50,000
Engineering and Administration	$1,200,000
Total Capital Costs	**$13,725,000**
Cap Maintenance, Net Present Worth ($5,000/yr)	$60,000
Continuing Certification for Institutional Controls, Net Present Worth ($10,000/yr)	$120,000
Net Present Worth, Capital and Maintenance (7%, 30 Yrs)	**$13,905,000**

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6.1.12 Alternative No. 9S-2 – Full Depth Selective Treatment by Soil Washing, Cap and IC

Alternative 9S-2 is the same as Alternative 9S-1 except instead of addressing a depth of six feet of soil containing visible elemental mercury, this alternative would be conducted within the area of visible elemental mercury (see Figure 2-5), to the lateral extent and depth (maximum of 17 feet from the RI data) defined by such observations.

The components of this remedy would be as follows:

- Site Preparation and Clearing: Same as Alternative No. 2S
- Excavation: Same as Alternative No. 9S-1, except that excavation would be based on the observed locations of visible elemental mercury documented in the RI,

with a corresponding maximum excavation depth of 17 feet. Excavation would also occur beneath the existing building footprints. The Site buildings are supported on pile foundations and numerous piles and pile caps could interfere with excavation. Consequently, this alternative would require further evaluation of the impacts of foundation structures on removal of the material to a depth of 17 feet.

- Soil Washing: Same as Alternative 9S-1
- Off-Site Disposal: Same as Alternative 9S-1
- Post-Excavation Confirmatory Sampling: Same as Alternative 4S-2
- Soil Cap: Same as Alternative No. 2S
- Soil Erosion and Sediment Controls and Site Restoration: Same as Alternative No. 2S
- Establish Use Restrictions: Same as Alternative No. 2S
- Miscellaneous: Same as Alternative No. 2S

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, soil washing, off-site disposal of soil which cannot be utilized for site backfill, cap installation, soil erosion and sediment controls, and site restoration activities. Costs for cap installation represent an average of the two possible capping limits (i.e., with or without overfill of SBC). In addition, capital costs to establish the institutional controls are included based on experience. Annual maintenance and inspection costs are included for the cap, which would include necessary maintenance and repairs (e.g., mowing, repairs to erosion related damage) as well as site inspections to support the required institutional and engineering control certifications. In addition, annual costs are included for the biennial certification for institutional/engineering controls that would remain for the Site. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 30 years. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$200,000
Excavation and Backfill	$1,800,000
Soil Washing	$5,900,000
Off-Site Disposal (Hazardous)	$500,000
Post-Excavation Confirmatory Sampling	$25,000
Capping	$5,800,000
Soil Erosion Controls/Site Restoration	$100,000
Establish Use Restrictions	$50,000
Miscellaneous (HASP, permits, survey)	$50,000

Capital Costs (continued)	
Engineering and Administration	$1,400,000
Total Capital Costs	**$15,825,000**
Cap Maintenance, Net Present Worth ($5,000/yr)	$60,000
Continuing Certification for Institutional Controls, Net Present Worth ($10,000/yr)	$120,000
Net Present Worth, Capital and Maintenance (7%, 30 Yrs)	**$16,005,000**

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6.1.13 Alternative No. 10S – Excavation and Off-Site Disposal

Alternative 10S would provide for the removal of Site soils with concentrations of constituents above the NRDCSRS. This alternative provides a baseline cost for site restoration to predevelopment conditions, and so would include removal of all the anthropogenic fill placed above the marine tidal marsh deposits. Excavated soil would be transported off-site for treatment and/or disposal.

The components of this remedy would be as follows:

- Site Preparation and Clearing: Same as Alternative No. 2S
- Excavation and Off-Site Disposal: Soils contaminated above applicable criteria would be excavated and stockpiled for disposal characterization. As mentioned in Section 2, the entire anthropogenic fill material layer, as well as parts of the tidal marsh and glacial till deposits would be excavated. The estimated excavation volume for this alternative is approximately 380,000 cubic yards. Sheeting and shoring would be required around portions of the property boundary due to excavation depth (i.e., where greater excavation depths would border adjacent properties not otherwise supported). In addition, dewatering would be necessary at greater excavation depths to permit control of the excavation process in the dry. It is assumed that soils excavated from the Closed RCRA Unit and the areas of soil containing visible elemental mercury would be managed as described for Alternative Nos. 4S-1 and 4S-2, with at least a portion of the soil with visible elemental mercury managed as hazardous waste and all of the Closed RCRA Unit brine sludge managed as hazardous waste as the material in the Closed RCRA Unit, once removed, would be a listed waste (K071).
- Post-Excavation Confirmatory Sampling: Post-excavation sampling would be conducted in a manner generally consistent with the NJDEP *Technical Requirements for Site Remediation*. Samples would be analyzed for metals, VOCs, SVOCs and PCBs. Recognizing that the Site is contained within an industrial area characterized by anthropogenic fill, the potential exists for off-site contamination unrelated to the Site. Post-excavation confirmatory sampling would primarily be targeted to verifying that contaminated soil has been removed along the bottom of the excavation area.

- Backfill: Following the completion of the post-excavation confirmatory samples, the excavation areas would be backfilled with certified clean fill and graded as appropriate for the installation of a vegetated cover soil layer.
- Soil Erosion and Sediment Controls and Site Restoration: Same as Alternative No. 2S
- Miscellaneous: Same as Alternative No. 2S

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, removal and off-site disposal of soils, soil erosion and sediment controls, and site restoration activities. Since the site would be restored, operation and maintenance costs would not be incurred. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$200,000
Excavation and Backfill	$17,900,000
Off-Site Disposal (Both Hazardous & Non-Hazardous)	$139,300,00
Post-Excavation Confirmatory Sampling	$75,000
Soil Erosion Controls/Site Restoration	$100,000
Miscellaneous (HASP, permits, survey)	$50,000
Engineering and Administration	$1,800,000
Total	**$159,425,000**

6.2 Groundwater Alternatives Development

6.2.1 Alternative No. 1GW – No Action

Alternative No. 1GW is intended as a baseline for comparison of other alternatives. No actions would be taken nor would any existing actions (e.g., use restrictions) be continued. There would not be any costs associated with this alternative.

6.2.2 Alternative No. 2GW – Capping and Barrier Wall, Shallow Groundwater Collection and Treatment, Long-Term Monitoring of Deep Groundwater and Institutional Controls

Alternative No. 2GW consists of both containment and collection of the overburden groundwater. Containment portions of the remedy consist of the installation of a low-permeability sheet pile barrier wall and soil cap. Shallow groundwater would be collected and conveyed to either the existing LPH wastewater treatment plant or discharged to a POTW for treatment. This alternative would contain the shallow groundwater within the limits of the site and control migration of contaminated groundwater.

As described in Section 2.3.3, the bedrock groundwater is classified as IIIB, and therefore, assessment of groundwater quality is through comparison to surface water quality criteria in the vicinity of the groundwater discharge zone along the Arthur Kill. This comparison shows that only arsenic and manganese are found in concentrations above the surface water quality criteria, and these are not site-operations-related constituents and are most likely associated with the fill, other sources, or are naturally occurring. The data, therefore, do not indicate the potential for an impact on surface water quality from groundwater discharge from the bedrock. Upgradient of the Arthur Kill, the distribution of groundwater quality impacts is indicative of impacts associated with the adjacent LPH site rather than indicative of impacts from the LCP site. Chlorobenzene is associated with the adjacent LPH site, as is more soluble mercury, both of which are found in the northwestern portion of the site, but not down-gradient or adjacent to the former chlor-alkali operations. The only bedrock wells that contain detectable levels of mercury are located northwest of the LCP production area. Groundwater in the bedrock water-bearing zone that enters the LCP site from the up-gradient site is re-captured and subsequently treated by the LPH remediation system. As a result of this understanding of conditions in the bedrock aquifer, the only component of the remedy associated with the bedrock groundwater is monitoring.

Deleted: Up gradient of the Arthur Kill, the distribution of groundwater quality impacts is indicative of impacts associated with the adjacent LPH site and is not associated with LCP.

Overall, the components of this remedy would be as follows:

- Site Preparation and Clearing: Site clearing would consist of removal of surface cover (e.g., vegetation) that could interfere with installation of a cap, barrier wall, and shallow groundwater collection system. Existing site structures (e.g., buildings, tanks, etc.) would be demolished and disposed of as part of the Building Debris alternatives, discussed subsequently. Site preparation would consist of various initial preparatory activities (soil erosion and sediment controls, temporary facilities, etc.) to facilitate remedy implementation.
- Soil Cap: Same as Alternative No. 2S
- Barrier Wall: Same as Alternative No. 3S
- Shallow Groundwater Collection System: A shallow groundwater collection system would be installed along the interior limits of the barrier wall to control groundwater within the contained area. It is anticipated that this collection system would be designed similar to that currently installed at the adjacent LPH site, and would consist of a shallow collection pipe with manholes and pump stations as appropriate. Given the shallow nature of the overburden groundwater, collection is more appropriate through a linear drain system than individual wells. If appropriate, the ends of the collection trench could be connected to the existing

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LPH system by gravity as an alternative if the systems were combined for discharge. Currently, LPH is pursuing an alternative discharge of its collected groundwater to the Linden-Roselle POTW, although at present groundwater is treated in an on-site treatment plant with local discharge to the Arthur Kill. Because of the similarities of the groundwater collection systems at the site, it is anticipated that discharge from the LCP overburden groundwater collection system would be managed similarly to the LPH system. The details of the collection system and final point of treatment would be developed during the final design. For the purpose of the cost estimate for this FS, however, the assumption has been made that discharge from the LCP Site will be to the POTW. One additional aspect of overburden groundwater relevant to this alternative is that the shallow groundwater table is a result of local infiltration of precipitation; the overburden groundwater is not a regional aquifer. As a result, if the Site is capped and infiltration is cutoff, the groundwater table will decline and ultimately the overburden aquifer would be expected to dry out. As a result, in developing costs for this alternative, management of overburden groundwater is included for a period of ten years, which is a reasonable estimate for decline of the overburden groundwater table. The estimated flow rate during this time period, is as presented in Section 2.7.2, and is approximately 1.6 gallons per minute.

- Soil Erosion and Sediment Controls and Site Restoration: Same as Alternative No. 2S
- Establish Use Restrictions: An institutional control in the form of a classification exception area (CEA) would be established for areas where the groundwater contains constituent concentrations above groundwater quality standards. The CEA would apply to the overburden groundwater, as the bedrock groundwater is already not suitable for potable purposes and is classified as IIIB. The CEA would also include a biennial certification component to confirm that the nature (i.e., constituents) and extent (lateral and vertical limits) of the CEA remain protective.
- Groundwater Monitoring: Groundwater monitoring would be performed to assess the performance of the remedy and is assumed to include both elevation and groundwater quality data. Elevation data would be used to assess continued capture of the bedrock groundwater in the adjacent LPH site system and the performance of the overburden groundwater collection system. Groundwater quality data would be used to assess that the down-gradient bedrock groundwater quality remains consistent with surface water quality criteria, as previously described. Typically, groundwater monitoring is performed on a quarterly basis and this is assumed for this alternative as well, although as data are collected it is

not uncommon to decrease the data collection frequency based on consistency of results.

- Miscellaneous: Same as Alternative No. 2S

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, cap and barrier wall installation, installation of the shallow groundwater collection system, soil erosion and sediment controls, and site restoration activities. In addition, capital costs to establish the institutional controls are included based on experience. Annual maintenance and inspection costs are included for the cap; routine maintenance is not necessary for the barrier wall. The cap maintenance and inspection activities would include necessary maintenance and repairs (e.g., mowing, repairs to erosion related damage) as well as site inspections to support the required institutional and engineering control certifications. In addition, annual costs are included for the biennial certification for institutional/engineering controls that would remain for the Site, for groundwater monitoring, and for groundwater discharge associated with a direct discharge to the POTW. Annual maintenance, inspection, and monitoring costs are converted to a net present worth using a discount rate of five percent over a period of 30 years, although for the groundwater discharge component, the cost over the estimated 10-year duration is converted to an equivalent 30-year duration for ease of presentation at this screening stage of the process. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$200,000
Capping and Barrier Wall	$8,400,000
Shallow Groundwater Collection System	$1,100,000
Soil Erosion Controls/Site Restoration	$30,000
Establish Use Restrictions	$50,000
Miscellaneous (HASP, permits, survey)	$50,000
Engineering and Administration	$1,000,000
Total Capital Costs	**$10,830,000**
Cap Maintenance, Net Present Worth ($5,000/yr)	$60,000
Continuing Certification for Institutional Controls, Net Present Worth ($20,000/yr)	$250,000
Groundwater Monitoring, Net Present Worth ($30,000/yr)	$370,000
Groundwater Treatment/Discharge (POTW), Equivalent Net Present Worth, ($500/yr)	$10,000
Net Present Worth, Capital and Maintenance (7%, 30 Yrs)	**$11,520,000**

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6.2.3 Alternative No. 3GW – Shallow Groundwater Collection and Treatment, Long-Term Monitoring of Deep Groundwater and Institutional Controls

Alternative No. 3GW is similar to Alternative No. 2GW, except that the barrier wall and cap are not included. A barrier wall is typically used in groundwater containment remedies to reduce inflow of groundwater from outside of the desired capture limits, and is not typically needed to establish hydraulic control. Similarly, a cap reduces infiltration and, therefore, the quantity of groundwater collected, but is also not needed for hydraulic control. This alternative, therefore, represents an option that relies on hydraulic control for groundwater containment. Because a cap is not a component of this alternative, infiltration of precipitation will continue at its current rate and, therefore, the overburden groundwater table will not decline over time. Therefore, this alternative also considers long-term groundwater collection and treatment. The remaining aspects of this alternative are the same as Alternative No. 2GW.

The components of this remedy would be as follows:

- Site Preparation and Clearing: Site clearing would consist of removal of surface cover (e.g., vegetation, pavement) to facilitate installation of the shallow groundwater collection system. Other site preparation activities would be the same as Alternative No. 2GW.
- Shallow Groundwater Collection System: Same as Alternative No. 2GW, except that groundwater collection and treatment would continue for the long-term, as noted above. The typical 30-year planning horizon has, therefore, been used for groundwater collection and treatment. The estimated flow rate during this time period, is as presented in Section 2.7.2, and is approximately 20 gallons per minute.
- Soil Erosion and Sediment Controls and Site Restoration: Same as Alternative No. 2S
- Establish Use Restrictions: Same as Alternative No. 2GW
- Groundwater Monitoring: Same as Alternative No. 2GW
- Miscellaneous: Same as Alternative No. 2S

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, installation of the shallow groundwater collection system, soil erosion and sediment controls, and site restoration activities. In addition, capital costs to establish the institutional controls are included based on experience. Annual maintenance and inspection costs are included to support the required institutional and engineering control certifications. In addition, annual costs are included for the biennial certification for institutional/engineering controls that would remain for the Site, for groundwater monitoring and for groundwater discharge costs associated with the direct discharge to the POTW. Annual maintenance, inspection, and monitoring costs are converted to a net present worth using a discount rate of five percent over a period of 30 years. The estimated costs are summarized as follows:

Capital Costs

Site Preparation and Clearing	$100,000
Shallow Groundwater Collection System	$1,100,000
Soil Erosion Controls/Site Restoration	$30,000
Establish Use Restrictions	$50,000
Miscellaneous (HASP, permits, survey)	$50,000
Engineering and Administration	$100,000
Total Capital Costs	**$1,430,000**
Continuing Certification for Institutional Controls, Net Present Worth ($7,500/yr)	$250,000
Quarterly Groundwater Monitoring, Net Present Worth ($30,000/yr)	$370,000
Groundwater Treatment/Discharge (POTW), Net Present Worth, ($10,000/yr)	$120,000
Net Present Worth, Capital and Maintenance (7%, 30 Yrs)	**$2,170,000**

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6.3 Sediment Alternatives Development

6.3.1 Alternative No. 1SD– No Action

Alternative No. 1SD is intended as a baseline for comparison of other alternatives. No actions would be taken nor would any existing actions (e.g., use restrictions) be continued. There would not be any costs associated with this alternative.

6.3.2 Alternative No. 2SD – Erosion Controls and New Benthic Layer, and Restore/Mitigate Disturbed Wetlands

Alternative No. 2SD consists of placing a new benthic layer over the existing sediment bed to provide a clean habitat for sediment dwelling organisms, and to control the potential for transport of contaminated sediments. Placement of the new benthic layer would include erosion controls so that the clean benthic layer would remain and underlying contaminated sediments would not be exposed once placed, from either tidal exchange or surface water runoff. In addition, the wetlands along the banks of South Branch Creek would be restored and/or mitigated to provide a functional wetland system

The components of this remedy would be as follows:

- Site Preparation and Clearing: Site clearing would consist of vegetation removal and other site preparation activities (e.g., water diversion) to facilitate remedy implementation.
- New Benthic Layer: Typically, benthic organisms inhabit no more than the upper 12 inches of the sediment surface. This alternative would, therefore, include a new 12-inch layer of clean sediments placed over both the existing sediments of South Branch Creek and the adjacent low marsh soil areas along the creek channel banks along with the sediments of the Northern Off-Site Ditch. To manage the potential for erosion of the new benthic layer that would expose underlying contaminated sediments, an erosion control layer would be placed

below the new benthic layer. This erosion control layer could be made of either geosynthetics or natural materials such as stone.

Restore/Mitigate Wetlands: The existing wetlands along South Branch Creek have been classified an intermediate resource value wetland by the NJDEP. During the on-Site habitat assessment conducted as part of the RI, these wetlands were found to be highly degraded and of relatively low habitat quality. Following the remediation of the South Branch Creek and Northern Off-Site Ditch sediments, the adjacent wetlands would be restored/mitigated to the extent practicable so that these wetlands are representative of an intermediate resource value wetland. Restoration would occur where the wetlands are temporarily disturbed to complete the sediments remediation. To the extent an alternative would fill an existing wetland, compensatory mitigation would be performed. Mitigation could be in the form of a wetland bank, in-lieu fee, on-site mitigation, or mitigation at an alternative location. The mitigation could also include enhancing the resource value of the wetland. In New Jersey, restoration is typically at a ratio of 2:1 (restoration to disturbance), enhancement at a ratio of 3:1 to 10:1, and banking at a ratio of 1:1. The details of the wetland restoration and mitigation would be defined as a part of the remedy design and implementation approval (e.g., permit equivalent) process.

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, installation of a new benthic and erosion control layers, and to restore/mitigate the existing wetlands. Annual maintenance and inspection costs are included for necessary inspection, maintenance and reporting activities related to the wetland restoration/mitigation. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 5 years, representative of the length of time necessary to establish and document wetlands restoration/mitigation. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$40,000
New Benthic and Erosion Control Layer	$200,000
Restore/Mitigate Wetlands	$370,000
Engineering and Administration	$60,000
Total Capital Costs	**$670,000**
Maintenance of Wetlands, Net Present Worth ($25,000/yr)	$100,000
Net Present Worth, Capital and Maintenance (7%, 5 Yrs)	**$770,000**

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6.3.3 Alternative No. 3SD – Selective Excavation of Sediments, Place On-Site, and Restore/Mitigate Disturbed Wetlands

Alternative No. 3SD consists of removing the existing sediments in the downstream portion of South Branch Creek and from the Northern Off-Site Ditch and placing them within the upstream section of the creek. During the placement of the excavated sediments, additional fill material would be placed in the upstream section of the creek to facilitate the installation of a soil cap within this area, and the upstream portion of SBC would then be incorporated in the overall remedy for soils at the Site. This alternative is premised on the limited current habitat value of the upstream portion of SBC, and the likelihood of this portion of SBC never representing any significant habitat because of its location amidst a highly industrialized setting. Conversely, the lower portion of SBC is immediately adjacent to the Arthur Kill, and has greater habitat potential for the future, and therefore would be the focus of creek and wetlands restoration efforts. Following the removal of the existing sediments from the lower portion of SBC, the pre-construction bathymetry of South Branch Creek would be restored with clean sediment, as would the adjacent wetlands.

The components of this remedy would be as follows:

- Site Preparation and Clearing: Same as Alternative No. 2SD
- Excavation and Backfill: The sediments located downstream of the culvert in South Branch Creek would be removed to the maximum depth of the sediment layer as defined during the RI activities (i.e., ~2.5 feet deep). The low marsh soils downstream of the culvert would be removed to a depth of approximately one foot. In addition, the sediments in the Northern Off-Site Ditch would be removed to a depth of approximately 2.2 feet, on average. The excavated sediment/soil would be placed within the upstream portion of the creek. As noted previously for soil washing, a CAMU would be designated for placement of the excavated sediments on the Site. For costing purposes, if has been assumed that 50% of the excavated sediment would not meet LDR requirements and would be treated by ex situ S/S prior to placement in the upper portion of the SBC. Additional fill would be placed in the upstream portion of the creek to facilitate incorporation in the overall Site soils remedy. It is assumed that, in total, 2 feet of soil would be placed within the upstream portion of South Branch Creek.
- Northern Off-Site Ditch Outlet Extension: The Northern Off-Site Ditch appears to discharge to South Branch Creek east of the culvert bridge crossing which separates the upstream and downstream sections of SBC. Since this alternative involves the backfill of the upstream section of SBC to facilitate the installation of a soil cap, the existing outlet for the Northern Off-Site Ditch will be extended

approximately 250 feet in a culvert to the existing SBC culvert bridge crossing. In doing so, the Northern Off-Site Ditch will continue to discharge to SBC once the upstream section of SBC is backfilled.

- Restore/Mitigate Wetlands: Same as Alternative No. 2SD. In addition, to the extent practicable, wetlands disturbed during the filling of the upstream portion of South Branch Creek will be replaced/mitigated as previously described for Alternative 2SD.

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, excavation of existing sediments and low marsh soils, placement of excavated materials in the upstream section of South Branch Creek, extension of the existing Northern Off-Site Ditch outlet to SBC, and restoration/mitigation of the existing wetlands. Annual maintenance and inspection costs are included for necessary inspection, maintenance and reporting activities related to the wetland restoration/mitigation. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 5 years, representative of the length of time necessary to establish and document wetlands restoration/mitigation. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$40,000
Excavation and Backfill	$170,000
On-Site Placement	$360,000
Northern Off-Site Ditch Outlet Extension	$50,000
Restore/Mitigate Wetlands	$370,000
Engineering and Administration	$100,000
Total Capital Costs	**$1,090,000**
Maintenance of Wetlands, Net Present Worth ($25,000/yr)	$100,000
Net Present Worth, Capital and Maintenance (7%, 5 Yrs)	**$1,190,000**

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6.3.4 Alternative No. 4SD – Excavation of Sediments, Place On-Site, and Restore/Mitigate Disturbed Wetlands

Alternative No. 4SD is similar to Alternative No. 3SD, with the exception that the sediments and low marsh soils from the entire South Branch Creek would be excavated and placed on Site by incorporating the sediments in the overall soils remedy. The upstream portion of South Branch Creek would not be backfilled as part of this alternative.

The components of this remedy would be as follows:

- Site Preparation and Clearing: Same Alternative No. 2SD

- Excavation and Backfill: The South Branch Creek sediments would be removed to the maximum depth of the sediment layer as defined during the RI activities (i.e., ~2.5 feet deep). Low marsh soils downstream of the culvert would be removed to a depth of approximately one foot. In addition, the sediments in the Northern Off-Site Ditch would be removed to a depth of approximately 2.2 feet, on average. The excavated sediment/soil would be placed on Site, incorporating the sediments in the overall soils remedy. For costing purposes, if has been assumed that 50% of the excavated sediment would not meet LDR requirements and would be treated by ex situ S/S prior to placement on Site.

- Restore/Mitigate Wetlands: Same as Alternative No. 2SD.

The estimated costs for this alternative are based on capital costs for the site preparation and clearing, excavation of existing sediments and low marsh soils, placement of excavated materials on Site, including S/S as applicable, and restoration/mitigation of the existing wetlands. Annual maintenance and inspection costs are included for necessary inspection, maintenance and reporting activities related to the wetland restoration/mitigation. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 5 years, representative of the length of time necessary to establish and document wetlands restoration/mitigation. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$40,000
Excavation	$170,000
On-Site Placement	$590,000
Restore/Mitigate Wetlands	$370,000
Engineering and Administration	$120,000
Total Capital Costs	**$1,290,000**
Maintenance of Wetlands, Net Present Worth ($25,000/yr)	$100,000
Net Present Worth, Capital and Maintenance (7%, 5 Yrs)	**$1,390,000**

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6.3.5 Alternative No. 5SD – Excavation of Sediments, Dispose Off-Site, and Restore/Mitigate Disturbed Wetlands

Alternative No. 5SD is similar to Alternative No. 4SD, but instead of placing excavated sediments on the Site and incorporating them into the soils remedy, they would be disposed of off Site.

The components of this remedy would be as follows:

- Site Preparation and Clearing: Same as Alternative No. 2SD

- Excavation and Backfill: Same as Alternative No. 4SD

- Off-Site Disposal: The sediments contain various constituents, including mercury, at levels that have the potential to exceed the TCLP extract criteria for classification as a hazardous waste. While it would not be expected that the sediments would be hazardous, for the purpose of evaluating the cost of this alternative, it has been conservatively assumed that 50% of the excavated sediment/soil would be disposed of as hazardous waste.
- Restore/Mitigate Wetlands: Same as Alternative No. 2SD

The estimated costs for this alternative are based on capital costs for the site clearing, excavation of existing sediments and low marsh soils, off-site disposal, and restoration/mitigation of the existing wetlands. Annual maintenance and inspection costs are included for necessary inspection, maintenance and reporting activities related to the wetland restoration/mitigation. Annual maintenance and inspection costs are converted to a net present worth using a discount rate of five percent over a period of 5 years, representative of the length of time necessary to establish and document wetlands restoration/mitigation. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation and Clearing	$40,000
Excavation	$190,000
Off-Site Disposal (50% Hazardous)	$3,600,000
Restore/Mitigate Wetlands	$370,000
Engineering and Administration	$60,000
Total Capital Costs	**$4,260,,000**
Maintenance of Wetlands, Net Present Worth ($25,000/yr)	$100,000
Net Present Worth, Capital and Maintenance (7%, 5 Yrs)	**$4,360,000**

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6.4 Building Materials Alternatives Development

6.4.1 Alternative No. 1B– No Action

Alternative No. 1B is intended as a baseline for comparison of other alternatives. No actions would be taken nor would any existing actions (e.g., use restrictions) be continued. There would not be any costs associated with this alternative.

6.4.2 Alternative No. 2B – Demolish, Recycle Steel, Place Other Materials On-Site

The existing buildings and structures on the Site are in a state of disrepair and there is evidence that some of the porous building debris contains visible elemental mercury. To facilitate the implementation of both the soil and groundwater remedies, to remove the potential physical hazards associated with the state of disrepair of the buildings, and to address visible elemental mercury which may be present, the various buildings and structures on Site would be demolished. These buildings and structures are primarily constructed of masonry materials, although demolition debris would also consist of various steel supporting structures, tanks and piping materials external to the buildings. Alternative No. 2B consists of demolishing the buildings and other structures, placing the masonry debris on Site, and decontaminating (i.e., pressure washing) the steel and recycling it to the extent practicable. The debris that remains on Site would be incorporated in the overall remedy for the soils.

The components of this remedy would be as follows:

- Site Preparation: Site preparation would consist of various initial preparatory activities to facilitate building demolition (e.g., asbestos survey, safety controls).
- Building Demolition: Demolition of existing buildings and structures would be implemented using standard equipment and practices (explosive demolition would not be used because of the potential for dispersion of mercury) to dismantle the buildings in a controlled manner. Dust control, such as misting, would also be employed during demolition to aid in the control of dispersion of contaminants as the buildings are dismantled. Where visible elemental mercury is observed on the building surfaces, it would be removed to the extent practicable using vacuuming or other similar technique. However, because of the condition of the buildings, personnel would not be permitted to enter the buildings for this purpose. Rather, such activities would only be performed to the extent practicable as the buildings are dismantled. Following demolition, steel and other non-porous materials, if any, would be segregated, decontaminated as necessary, and recycled, to the extent practicable.
- Placement on Site: Following demolition, masonry and other non-recyclable building debris would be placed on Site by incorporating the material in the overall Site soils remedy (again a CAMU would be applicable). For the purpose of estimating costs, it is assumed that approximately 25% of the building debris contains elemental mercury, as evidenced by visible mercury during demolition. While the visible mercury would be removed to the extent practicable (e.g. vacuuming), some may remain in the porous building material. Building debris which is expected to contain elemental mercury would be mixed with sulfur prior to placement on Site, as an aid in controlling the vaporization of elemental mercury. Because of the presence of contaminants, particularly mercury, in the building materials, processing of the debris would be limited to only that necessary to reduce the size of the material for placement within the soils remedy area. As necessary, voids in larger debris can be “choked off” with smaller debris or soils, so that a suitable subgrade will exist for the final site conditions (e.g., cap for the soil remedy).

The estimated costs for this alternative are based on capital costs for the site preparation, demolition of buildings and structures, mixing a portion of the debris with sulfur, and on-Site placement. For recyclable materials, any benefits from steel recycling are assumed to net out with the cost of decontamination, handling, and transport. The estimated costs are summarized as follows:

Capital Costs	
Site Preparation	$25,000
Building Demolition	$4,630,000
Placement On-Site	$1,020,000
Engineering and Administration	$570,000
Total Capital Costs	**$6,245,000**

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6.4.3 Alternative No. 3B – Demolish, Recycle Steel, Dispose of Other Materials Off-Site

Alternative No. 3B is similar to Alternative No. 2B, except under this alternative the assumption is made that the building demolition debris would be disposed of off Site.

The components of this remedy would be as follows:

- Site Preparation: Same as Alternative No. 2B
- Building Demolition: Same as Alternative No. 2B
- Off-Site Disposal: This alternative is premised on all of the building debris being disposed of off the Site. Similar to Alternative No. 2B, steel and other non-porous debris, if any would be decontaminated and recycled. Porous debris, including the masonry would be disposed of in a landfill. For the purpose of estimating costs, it is assumed that approximately 75% of the building debris that is not recycled would be disposed in a local landfill as non-hazardous. Similar to alternative No. 2B, it is then assumed that 25% of the building debris contains elemental mercury, and would be disposed as hazardous. As previously noted, the only facility identified to date that could likely accept such materials is the USEcology/Stablex of Canada facility. Prior to disposal, building debris would be crushed to a suitable size for disposal, and appropriate vapor and dust controls would be incorporated. However, for the purpose of this alternative costing, the assumption has not been made that the demolition crushing would need to occur inside of an enclosure. However, if this alternative were selected, the need for an enclosure would be further evaluated during design.

The estimated costs for this alternative are based on capital costs for the site preparation, demolition of buildings and structures, debris handling and processing, and off-site disposal/recycling. Again, any benefits of recycling are assumed to net out. The estimated costs are summarized as follows:

Capital Costs		
Site Preparation	$25,000	
Building Demolition	$4,630,000	**Deleted:** 2,320
Off-Site Disposal (25% Hazardous)	$16,490,000	
Engineering and Administration	$470,000	**Deleted:** 230
Total Capital Costs	**$21,615,000**	**Deleted: 19,065**

6.4.4 Alternative No. 4B – Demolish, Recycle Steel, Placement of Other Materials Partially On-site and Off-Site Disposal of Remaining Debris

Alternative No. 4B is combination of Alternative Nos. 2B and 3B, where the non-hazardous building debris is assumed to remain on Site and be incorporated in the overall Site soils remedy, and the building debris which contains elemental mercury based on visual evidence during demolition, is assumed to be disposed off Site.

The components of this remedy would be as follows:

- Site Preparation: Same as Alternative No. 2B
- Building Demolition: Same as Alternative No. 2B
- On-Site Placement and Off-Site Disposal: The on-Site placement component of this alternative is the same as Alternative 2B. The off-Site disposal component of this alternative is the same as Alternative 3B for the material that would be considered hazardous (i.e., contain elemental mercury).

The estimated costs for this alternative are based on capital costs for the site preparation, demolition of buildings and structures, on-Site placement of non-hazardous debris and off-site disposal of hazardous debris. The estimated costs are summarized as follows:

Capital Costs		
Site Preparation	$25,000	
Building Demolition	$4,630,000	**Deleted:** 2,320
Placement On-Site	$310,000	
Off-Site Disposal (25% Hazardous)	$12,160,000	
Engineering and Administration	$500,000	**Deleted:** 270
Total Capital Costs	**$17,625,000**	**Deleted: 15,085**

6.5 Screening of Alternatives

The alternatives described above were screened against the criteria of effectiveness, implementability, and cost. For the purpose of the alternatives screening, these criteria were applied as follows:

- Effectiveness – Similar to the technology screening, this criterion is used to assess the ability of a technology to meet the remedial action objectives. Effectiveness is measured against meaningful goals including the alternative's ability to control potential exposure pathways or reduce risks. Effectiveness also considers items such as an alternative's ability to meet ARARs and short-term and long-term effects of implementation.

- Implementability – This criterion is used to assess the technical and administrative feasibility of implementing an alternative. Consideration is given to the practicability of implementing the technology used in the alternative, the ability to meet the substantive requirements of permitting regulations, the availability of the remedy components, and the timing for implementation.
- Cost – Cost is used to compare alternatives of otherwise similar effectiveness and implementability. If an alternative does not offer measurable and meaningful benefits and is otherwise similar, while costing more than another alternative, it can be eliminated from further consideration.

6.6 Retained Alternatives

The screening of the identified alternatives is presented in Table 6-1. Based on the results of the screening process, the following alternatives were retained because in general they are effective at meeting the remedial action objectives, controlling potential exposure, are protective of human health and the environment, provide either containment or treatment, are implementable, and are not redundant with another alternative of lesser cost:

Media	Alternative	Description of Alternative
Soil	Alternative No. 1S	No action
	Alternative No. 2S	Cap and Institutional Controls (IC)
	Alternative No. 4S-1	Partial Depth Selective Excavation, Capping, Off-Site Disposal and IC
	Alternative No. 4S-2	Full Depth Selective Excavation, Capping, Off-Site Disposal and IC
	Alternative No. 6S	Treatment Cap, Barrier Wall and IC
Soil	Alternative No. 8S-1	Partial Depth Selective Treatment by Stabilization, Cap and IC
	Alternative No. 8S-2	Full Depth Selective Treatment by Stabilization, Cap and IC
Groundwater	Alternative No. 1GW	No action
	Alternative No. 2GW	Cap and Barrier Wall, Shallow Groundwater Collection and Treatment, Long-Term Monitoring of Deep Groundwater and Institutional Control
	Alternative No. 3GW	Shallow Groundwater Collection and Treatment,

Media	Alternative	Description of Alternative
		Long-Term Monitoring of Deep Groundwater and Institutional Controls
Sediments	Alternative No. 1SD	No action
	Alternative No. 3SD	Selective Excavation of Sediments, Place On Site, and Restore/Mitigate Disturbed Wetlands
	Alternative No. 4SD	Excavate Sediments, Place On Site, and Restore/Mitigate Disturbed Wetlands
Building Debris	Alternative No. 1B	No action
	Alternative No. 2B	Demolish, Recycle Steel, Place Other Materials On Site
	Alternative No. 4B	Demolish, Recycle Steel, Placement of Other Materials Partially On Site and Off-Site Disposal of Remaining Debris

The alternatives which have been retained through the screening process, as listed above, form the basis for a logical set of combined site remedies. The combined remedies will allow for a manageable detailed evaluation process to address contamination at the Site as a whole. The detailed evaluation of the combined site remedies is described subsequently in Section 7.

6.7 Eliminated Alternatives

The alternatives that have been eliminated from further evaluation along with the rationale for elimination are described in the sections that follow.

6.7.1 Alternative No. 3S - Selective Mercury Removal, Capping, Barrier Wall and IC

Alternative No. 3S includes selective mercury removal via vacuuming. The vacuuming process would address surficial, visible elemental mercury similar to Alternative 6S which includes a treatment layer in the cap. Both of these alternatives focus on treatment of visible elemental mercury in surficial soils to aid in the control of the potential vapor exposure pathway. However, Alternative No. 3S is much more difficult to implement (i.e., manual vacuuming of soils with visible mercury) and is more costly than Alternative No. 6S without providing any meaningful additional benefits.

6.7.2 Alternative No. 5S - Cap, Barrier Wall and IC

Alternative No. 5S is similar to Alternative No. 6S, except that Alternative No. 5S is containment based (physical barriers), whereas Alternative No. 6S provides some treatment through the use of the treatment layer in the cap. This treatment layer provides an additional measure beyond the physical barrier of the cap to control the potential vapor exposure pathway for mercury or the potential for buildup of mercury vapor below the cap. This additional treatment layer adds minimal cost compared to Alternative No. 5S. Therefore, for the purpose of the retained alternatives evaluation, a treatment cap has been retained for each alternative that has a capping component, in lieu of solely a physical barrier.

6.7.3 Alternative No. 7S - Selective Treatment by Solidification / Stabilization, Cap and IC

The focus of Alternative No. 7S is solidification/stabilization (S/S) technology for elemental mercury, in particular soils that contain visible elemental mercury. S/S involves mixing contaminated soil with a reagent(s) to reduce the mobility of the constituents, reduce permeability of the soil, and limit leaching of constituents from the treated soil. Solidification is a physical process where constituents are bound or enclosed within a matrix. Stabilization is a chemical reaction between the stabilizing agent and constituents to reduce mobility. The most common S/S methods involve the use of pozzolanic materials such as Portland cement, fly ash, lime, or furnace slag (SAIC, 1998, USEPA, 2007). Solidification/stabilization of elemental mercury can also be performed with more advanced binders and proprietary compounds (e.g., sulfur amalgamation, microencapsulation) (USEPA, 2007, SAIC, 2005). Chemical leaching tests (TCLP) are used to evaluate the results of the treatment process. The following factors were considered in the evaluation of S/S applied to mercury impacted soil such as those found at the LCP Site:

- S/S of mercury wastes and elemental mercury have shown mixed results. Leachability following treatment is pH dependent. Leachability may increase at lower pH (SAIC, 2005), but may also increase at higher pH due to the potential formation of more soluble compounds such as mercurous sulfate (USEPA, 2007, USEPA, 2003). Solubility may also be affected by the concentration of major ions. For example, high chloride concentration, which is found at the LCP site, may increase leaching through the formation of more soluble mercury complexes (USEPA, 2003), such as mercuric chloride, which is highly soluble.
- Depending on the selection of the binder agent, mercury can be transformed into more mobile forms during treatment, leading to an increase in leachability of the treated soil compared to the untreated soil. In the case of pozzolanic-based binder agents, the high pH of the binder agent/soil mixture can cause mercuric sulfide, which has been identified in the RI as one of the dominant species of mercury found within the LCP Site soils, to be converted into the more soluble mercuric oxide (SAIC, 1998). Some studies have shown leachability increases for pozzolanic-based stabilization as high as 400 to 5,000 fold (SAIC, 1998)
- Elemental mercury is extremely dense and has high surface tension. As a result it does not readily dissolve, nor is it amenable to homogenous distribution with

additives used in the S/S process. As a result large volumes of additives are likely required for treatment, significantly increasing the bulk volume of the material after treatment (USEPA, 2003) when the goal is combined S/S. Three treatment options evaluated by USEPA (SAIC, 2005) for elemental mercury using proprietary compounds resulted in mass increase ratios of 1.63, 3.26, and 5.66.

- S/S of mercury waste is complicated due to the various forms of mercury, their wide range of mobility, and the complex behavior of the mercury species which results in certain S/S methods being appropriate for particular forms of mercury and not others.
- One of the more promising S/S processes for elemental mercury is the patented process using sulfur polymer cement (Brookhaven National Laboratories). However, to date this process has been demonstrated only at the bench, small scale level and involves a difficult set of procedures for translation to full, field scale (e.g., requires heating and/or extensive mixing for up to a day, inert atmosphere to control potential mercury off-gassing, completely enclosed system). The BNL process is also not currently commercially available, and has not been demonstrated at the scale required to treat the quantity of visible elemental mercury impacted soils at the LCP site. And, despite its promise, even this technology's ability to stabilize mercury may be subject to the variability evidenced in other S/S technologies, as was demonstrated in a leaching evaluation of mercury contaminated mixed wastes (Vanderbilt University, 2001), wherein soil treated with sulfur polymer cement resulted in a 100-times increase in mercury availability at pH 4 and 8 by comparison to untreated soil.

As described above in Section 2, mercury in the LCP Site soils is predominantly present in the form of cinnabar and elemental mercury, both of low solubility. As a result mercury migration in the subsurface has been limited as demonstrated by the relative absence of mercury in groundwater, even in the former chlor-alkali plant area where visible elemental mercury is present. Based on the fate and transport analysis presented in the RI, further migration of mercury is not anticipated. Thus, the goal of S/S would be to achieve similar conditions to those already found on the LCP site. That is, S/S typically reduces mobility and/or solubility; however, the mercury at the LCP is already present in low-solubility forms and is not mobile. When viewed in this context, and understanding the potential that S/S technologies have for actually increasing mercury availability/mobility, the S/S process has been eliminated from further consideration in deference to stabilization alone (i.e., chemical conversion), which does not present similar matrix issues with mercury mobility.

6.7.4 Alternative Nos. 9S-1 and 9S-2 - Selective Treatment by Soil Washing, Cap and IC

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The focus of Alternative Nos. 9S-1 & 9S-2 is soil washing technology for separation of elemental mercury, in particular from soils that contain visible elemental mercury. Soil washing is typically a water-based process for ex-situ removal of contaminants from soils. Contaminants are removed by suspending them in a wash solution and concentrating contaminants into a smaller volume through particle size separation. This concept is based on the finding that most organic and inorganic contaminants tend to bind to fines (i.e., clays, silts and organic soil particles). In soil, silts and clays are attached to other soil particles (i.e., sands and gravel) by physical processes such as compaction and adhesion. Suspending the soil in a solution allows for the separation of fines from the coarser soil particles, effectively concentrating the contaminants into a smaller volume of soil that can be further treated, if necessary, and disposed. As the fines content of the soil to be treated increases, the benefit of soil washing (i.e., volume reduction of contaminated soil) decreases (USEPA, 2007). USEPA data (USEPA, 2007) indicates difficulty in using soil washing at silt and clay fractions above 40 percent. In addition to the conventional application of soil washing for size separation, soil washing has also been used to separate elemental mercury from the soil matrix. A firm known as Highlands Remediation, Ltd. of British Columbia specializes in removal of elemental mercury from soils via a washing process. In this particular application then, not only are contaminants concentrated in the fines fraction, but elemental mercury is separated from both the fine- and coarse-grained soil fractions.

Borings conducted as part of the RI characterized the site soils using the Burmister soil classification system. This system uses textural size ranges as well as specific nomenclature to describe the soil's texture, color, plasticity and mineralogy. These classifications are able to approximate the general grain size ranges of soil samples. The boring logs for the LCP site samples were examined to estimate the percentage of fines within the fill and underlying tidal marsh deposits. The result of this analysis is shown in Appendix D. On average, fines account for at least 50%, if not more, of the fill and underlying tidal marsh deposits. For the Burmister soil classification system, fines are defined as being smaller than a 200 mesh sieve size (i.e., silts and clays). Considering that the definition of fines for the purpose of soil washing includes a slightly larger range of soil particle sizes (i.e., typically soil particles less than 120 mesh sieve size), based on the information shown in Appendix D, the expectation is that fine-grained soils predominate at the site.

Of particular interest in evaluating the potential applicability of soil washing at the LCP Site are the results of a soil washing operation by Highlands Remediation, Ltd at the LCP

Bridge Street Site in Syracuse, New York. Experience at the Bridge Street Site, provided by Highlands Remediation and as relevant to the LCP Site, indicates the following:

- The higher the fines content, the more difficult soil washing becomes. The fines content at the Bridge Street Site was generally in the range of only 10%.
- Even with the low fines content at the Bridge Street site, the soil washing operation reduced the average mercury concentration in the feed soils from approximately 2,200 mg/kg (arithmetic mean of sample batches tested) to approximately 640 mg/kg (also the arithmetic mean of sample batches tested). The 640 mg/kg concentration is of the coarse-grained, "cleaned" soil fraction. As points of comparison, the New Jersey NRDCSRS is 65 ppm, and the RCRA LDR (assuming the soil failed TCLP) is 260 mg/kg (i.e., above a mercury concentration of 260 mg/kg, the material is considered the high mercury waste subcategory). Assuming similar performance at the LCP Site, all of the material that is run through the washing process would still be considered waste.
- Mercury was concentrated in the fines generated during the Bridge Street project. The post-washing average concentration of mercury in the fines was approximately 2,600 mg/kg compared to the 2,200 mg/kg in the feed. However, even more important TCLP samples collected from excavated soils prior to soil washing showed 5 of 30 samples above the 0.2 mg/L hazardous waste classification limit for mercury. Following soil washing, the separated fines showed 26 of 34 TCLP samples above the 0.2 mg/L limit. Thus, the fines required additional treatment in the form of S/S prior to placement on-site beneath a capped area. While this was manageable for a site where a total of only about 6,500 cubic yards was washed, and only about 10% of this material was fine-grained, for the LCP Site, the fines would more likely be on the order of 9,000 cubic yards for the partial depth soil washing alternative (depending on actual TCLP failures), or more as previously explained.
- Following S/S of the Bridge Street site fines which were classified as hazardous waste, 5% of the stabilized material was unable to be treated below the 0.2 mg/L TCLP limit and was disposed of offsite as a hazardous waste.
- The percentage of fines also controls production rate, and experience at the Bridge Street Site has resulted in development of modifications to equipment and procedures to help manage fines. However, the production difficulties experienced at the Bridge Street site were for a low fines content soil.
- The aggressive soil washing operation will result in a greater potential for mercury vapor emissions. Figure 6-1 illustrates mercury vapor emissions for a soil washing project performed by Highlands Remediation, Ltd., in Squamish,

British Columbia. As shown on Figure 6-1, mercury vapor emissions were orders of magnitude higher than baseline conditions during the soil washing operation. For reference, the annual average chronic reference air concentration for mercury has been added to Figure 6-1. This air concentration has been used as an emissions benchmark for control of mercury vapors, most recently at the Ventron/Velsicol Superfund site where mercury contaminated soils were excavated for disposal off site. As Figure 6-1 illustrates, the mercury vapor emissions during soil washing are orders of magnitude above this benchmark value.

More recently, a major soil washing operation was started at a former chlor-alkali plant site in Sydney, Australia known as the Botany site. This former chlor-alkali plant resulted in mercury contamination similar to that at the LCP Site. Preparations for this former chlor-alkali remediation project commenced in July 2010 and full-scale operations commenced in April 2011. Air emissions are being managed during the remediation work through the use of a temporary building enclosure fitted with emission control systems, which encloses the soil washing plant and the main excavation area. The building is on the order of 130,000 square feet. However, in August 2011, the responsible party suspended the soil washing operations, at least temporarily. The stated reasons for the suspension of operations were reliability and production rate. Apparently the soil washing system is being re-evaluated to determine if improvements can be made to the system prior to the resumption of operations.

Based on the collective information presented above, the soil washing alternatives were eliminated from further consideration, and the rationale for eliminating this technology may be summarized as follows:

- The high fines content of the soil (predominantly fill) present on the Site would typically not qualify the material for soil washing, because soil washing is designed to concentrate contaminants in a small mass of fines, and is a technology typically applied to coarser-grained soils. If soil washing were implemented, mercury would be concentrated in at least 50% of the processed soil and contaminated soil volume reduction, therefore, would not be substantial.

- In addition, the washed fines would have a high moisture content creating a more difficult material to handle. Soils that did not previously fail for the TCLP or LDR ARARs, would potentially now fail creating additional handling and disposal issues for both on-Site and off-Site options.

- If further processing were required to manage the fines for moisture (e.g., solidification/stabilization), then the volume would be increased and the net result of the processing operation would be that a larger volume of material not meeting cleanup criteria may need to be managed than existed prior to processing, this is especially true if even the "cleaned" coarse-grained fraction would have mercury concentrations above any relevant chemical-specific ARARs such as the New Jersey NRDCSRS.

- The aggressive nature of the soil washing operation increases the likelihood of mercury vapor emissions. Most likely, the operation would have to be performed in an enclosure, further complicating implementation of this alternative.

- The stabilization alternatives (8S-1 and 8S-2) provide a treatment-based alternative that meets the RAOs in a manner similar to soil washing, with fewer implementability issues, and at a lower cost.

6.7.5 Alternative No. 10S - Excavation and Off-Site Disposal

As previously described, Alternative No. 10S is designed to assess the feasibility of restoration of the Site to pre-release conditions. To achieve pre-release conditions not only would require remediation of contamination associated with the former LCP operation, but would also require the excavation and off-site disposal of the anthropogenic, historically placed fill. Historic fill is common in developed areas of New Jersey, and the typical remediation is not restoration to pre-release conditions for this material. Rather, the most common remedial approach, especially for larger areas of historic fill, is some form of physical barrier and institutional controls. In fact, recently, pursuant to its regulatory reforms, the NJDEP issued presumptive remedy guidance (NJDEP, July 2011) applicable to new residential construction, child care centers, public schools, private schools, and charter schools. In all cases, even for these more sensitive uses, the presumptive remedies are barriers, buffers, demarcation, and institutional controls. In addition, implementation of this remedy would result in extensive truck traffic through the residential streets leading to the site and public exposure to increased emission levels associated with such traffic. At a cost that is substantially higher than other alternatives that are consistent with remediation of historic fill in combination with site-related releases, the full excavation and off-site disposal alternative was eliminated from further consideration

6.7.6 Alternative No. 2SD - Erosion Controls and New Benthic Layer, and Restore/Mitigate Disturbed Wetlands

Alternative No. 2SD would cover contaminated sediments with new erosion control and benthic layers. The principal reasons for eliminating this alternative are that placement of the new erosion control/benthic layer would likely alter tidal exchange and the associated ecology of South Branch Creek (this alternative would in effect fill SBC), and it is also likely that bioturbation of the new benthic layer could cause recontamination of the sediments. In addition, the placement of fill within the Northern Off-Site Ditch would most likely negatively impact the conveyance capacity of the ditch. This alternative is also not appreciably less costly than some of the other sediments alternatives.

6.7.7 Alternative No. 5SD - Excavate Sediments, Off-Site Disposal and Restore/Mitigate Disturbed Wetlands

Alternative No. 5SD is similar to the other sediments alternatives where contaminated sediments are excavated and managed on Site, however, for this alternative the sediments would be disposed of off Site. By comparison to the Site soils that are likely to remain on the Site within containment (i.e., the site restoration to pre-release conditions is not practicable and was eliminated as noted above), the sediments would be of similar contaminant characteristics and would not alter potential future Site risks. Therefore, at a substantially greater cost than the alternatives that manage sediments on Site, off-Site disposal is not more protective nor does it offer other advantages relative to meeting the RAOs.

6.7.8 Alternative No. 3B - Demolish, Recycle Steel, Dispose of Other Materials Off-Site

This alternative includes off-Site disposal of all building debris. Similar to the reasons for eliminating the full off-Site disposal of sediments alternative, the building debris or portions of the building debris remaining on Site would be similar in contaminant characteristics to the soils that will remain and would not alter potential future site risks. Therefore, at a substantially higher cost than alternatives that manage all or a portion of the building debris on Site, off-Site disposal is not more protective nor does it offer other advantages relative to meeting the RAOs.

7 DETAILED ANALYSIS OF ALTERNATIVES

7.1 Development of Site Remedies

As described in Section 6, the alternative screening process results in sixteen alternatives remaining for detailed evaluation, seven for soils, three for groundwater, three for sediments and three for building materials. Discounting the no action alternatives from these sixteen, as the purpose of the no action alternatives is a baseline for comparison of other alternatives, then 12 alternatives remain which can be combined to develop Site-wide remedies. These 12 medium-specific alternatives can be combined to form as many as 36 possible combinations. To allow for a manageable detailed evaluation process, the medium-specific alternatives were examined in a logical manner to produce a representative number of combined site remedies that could be evaluated without affecting the outcome of the evaluation process, and in accordance with the regulations. These representative, combined site remedies were created from the medium-specific alternatives as follows:

- Soils: As illustrated through the screening process of the site media to be addressed, remediation of soil results in the greatest number of alternatives (7 including no action). In addition, the soils remediation alternatives are larger in scope than any other media. Consequently, the medium-specific remedy combination process uses the soil alternatives as a base for the creation of the combined site remedies. That is, the soils remedies can be varied without varying the other media remedies provided the other media remedies do not have an impact on the detailed evaluation process. In addition, the soil remedies contain two options for the areal extent of the cap, which is a component of each retained soils alternative. The limits of the cap are related to the selection of a sediment alternative (i.e., to overfill or to not overfill the upstream section of SBC). The difference in cost between overfilling and not overfilling the upstream section of SBC is nominal, on the order of approximately 10%. In addition, as previously noted, the upstream section of SBC is of limited habitat value and there is a minimal likelihood of this portion of SBC being restored to any significant value given its confined location within a highly industrialized area. Overall, therefore, the one cap alternative that includes filling over the upstream portion of SBC can be used in the detailed evaluation process without affecting the process because varying this assumption will not materially affect the remedy effectiveness or cost. As such, for the purposes of simplifying the detailed evaluation process, combined site-wide remedies include overfill of the upstream section of SBC.

- Groundwater: Two alternatives resulted from the alternative screening process, both of which include groundwater collection, one without containment and one with containment (cap and barrier wall). However, each of the soils remedies includes a containment component, which has a major influence on groundwater collection by cutting off infiltration. Therefore, Alternative No. 3GW (i.e., groundwater collection without containment) could not actually be combined with any of the soils remedies, even though on its own it is an alternative that passed the initial screening. As a result, Alternative No. 2GW is the only shallow groundwater alternative evaluated as part of each of the combined site remedies.
- Sediments: As described above, two alternatives survived the screening process, one that includes filling the upstream portion of SBC and one that does not. For reasons described above (the upstream section of SBC is of limited habitat value and there is a minimal likelihood of this portion of SBC being restored to any significant value given its confined location within a highly industrialized area) for the soils portion of the combined site remedies, only the sediments alternative that includes filling of the upstream portion of SBC will be used. If at some future time as part of the final remedy selection process or during remedy implementation a decision was reached to attempt to restore all of SBC, the cap would become slightly smaller, the cap cost would be nominally reduced, the sediment remedy cost would increase (less than the cap cost differential), and none of these changes would affect the evaluation of the alternatives. There are otherwise no overall differences in the effectiveness of these sediments alternatives.
- Building Debris: The two retained building debris alternatives differ only in that one involves managing the debris entirely on site, and the other includes managing a portion of the debris (that which contains visible elemental mercury) off-site and the balance on site. It would be logical to handle the debris similarly to the soils. So, for example, if the site-wide remedy involves on-site management of soil containing visible elemental mercury (i.e., in-situ stabilization or capping), logically then building materials containing visible elemental mercury would also be managed in the same manner (e.g., stabilized to the extent practicable and placed on-site as in Alternative No. 2B). Similarly, for a site remedy which includes off-site disposal of soil containing visible elemental mercury, logically building debris containing visible elemental mercury would also be disposed of off-site (i.e., Alternative No. 4B). This approach not only

simplifies the alternative evaluation process, but also makes the alternatives internally consistent between the soils and building materials.

Based on the above, the retained media-specific alternatives were combined into site-wide remedies, as follows:

1. No action (baseline for comparison of other alternatives)

2. Partial Containment (Treatment Cap) – this alternative focuses on capping as the primary soils remediation component and is combined with shallow groundwater collection, sediments remediation, and building demolition.

3. Full Containment (Treatment Cap and Barrier Wall) – this alternative represents the containment-based option for the site soils and groundwater including the barrier wall component for lateral control of potential contaminant migration. The remedy also includes shallow groundwater collection, sediment remediation, and building demolition.

4a. Full Containment and Partial Depth Selective Stabilization – this alternative adds a treatment component (stabilization) for soils containing visible elemental mercury to the full containment-based remedy, to a maximum depth of six feet. The remedy also includes shallow groundwater collection, sediment remediation, and building demolition.

4b. Full Containment and Full Depth Selective Stabilization – this alternative is the same as No. 4a, but is not depth limited.

5a. Full Containment and Partial Depth Selective Excavation and Off-Site Disposal – this alternative focuses on off-site disposal of soils containing visible elemental mercury as a remedial component with the maximum depth of excavation limited to six feet. The remedy also includes shallow groundwater collection, sediment remediation, and building demolition.

5b. Full Containment and Full Depth Selective Excavation and Off-Site Disposal – this alternative is the same as No. 5a, but is not depth limited.

The components of the above alternatives are summarized on Table 7-1, and the sections that follow provide more detailed descriptions of each along with an evaluation against the seven criteria as described in the *National Contingency Plan* and *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.* While detailed discussions and evaluations of these site remedies are presented in the sections that follow, a summary of this detailed evaluation of the site remedies in comparison to the FS evaluation criteria is presented in Tables 7-2a (threshold criteria) and Table 7-2b (balancing criteria). Table 7-3 then presents a comparative analysis of the seven site remedies against the evaluation criteria. In addition, an overall ranking is presented for each alternative based on its ability to meet the evaluation criteria, for ease of comparison of the alternatives.

7.2 Description of Combined Site Remedies

The site-wide remedy descriptions that follow are developed in sufficient detail to permit evaluation using the criteria described in Section 7.3, and for the preparation of cost estimates.

7.2.1 Site Remedy No. 1, No action

Combined Site Remedy No. 1 is intended as a baseline for comparison of other site remedies. This alternative would not include any future actions nor would it continue any existing activities (e.g., site restrictions). This alternative would also not have any costs associated with it, as it does not require any action.

7.2.2 Site Remedy No. 2, Partial Containment (Treatment Cap)

Site Remedy No. 2 primarily consists of a partial containment remedy (i.e., cap) for soils within the boundaries of the LCP site, along with groundwater, sediments, and building materials components. The components of this remedy are illustrated on Figure 7-1, and include the following:

- Site Preparation and Clearing: Site clearing would consist of removal of surface cover (i.e., vegetation, pavement) to facilitate installation of a cap and shallow groundwater collection system. Site preparation would consist of various initial preparatory activities to facilitate remedy implementation (e.g., survey, health and safety, staging areas, etc.).
- Treatment Cap: The soil cap would be installed site wide within the boundaries of the LCP Site (~24 acres) except for a small portion of the property to the southeast that is occupied solely by railroad tracks. The cap area would also include the upstream section of SBC to be filled with soil, sediments from the downstream portion of SBC, or other suitable material, and capped. The cap would consist of 24 inches of certified clean fill and would be able to support vegetation. A geosynthetic membrane to control mercury vapor and a geocomposite drainage layer for drainage control would be included. The cap would be graded to provide for positive drainage. Details of the capping and grading activities would be developed during design and would be integrated with Site redevelopment, where applicable. The treatment cap includes a component to control mercury vapor below the cap. This treatment component of the cap would consist of a three-inch thick layer of powdered elemental sulfur, placed

underneath the geosynthetic membrane component of the cap. The sulfur treatment layer would be placed in the area of visible elemental mercury, as shown on Figure 7-1. This sulfur layer would convert mercury vapor to metacinnabar below the cap. Treatability testing would be required prior to remedy implementation to determine the optimal sulfur-based compound to be utilized and the required treatment layer thickness to provide for a long-term reactive zone to treat mercury soil vapor which could accumulate below the cap.

- Shallow Groundwater Collection System: A shallow groundwater collection system would be installed along the perimeter of the cap (~ 5,300 linear feet) to control groundwater within the area contained below the cap. It is anticipated that this collection system would be designed similar to that currently installed at the adjacent LPH site, and would consist of a shallow collection pipe with manholes and pump stations as appropriate. Given the shallow nature of the overburden groundwater, collection is more appropriate through a linear drain system than individual wells. If appropriate, the ends of the collection trench could be connected to the existing LPH system by gravity as an alternative if the systems were combined for discharge. Currently, LPH is pursuing an alternative discharge of its collected groundwater to the Linden-Roselle POTW, although at present groundwater is treated in an on-site treatment plant with local discharge to the Arthur Kill. Because of the similarities of the groundwater collection systems at the site, it is anticipated that discharge from the LCP overburden groundwater collection system would be managed similarly to the LPH system. The details of the collection system and final point of treatment would be developed during the final design. For the purpose of the cost estimate for this FS, however, the assumption has been made that discharge from the LCP Site will be to the POTW. One additional aspect of overburden groundwater relevant to this alternative is that the shallow groundwater table is a result of local infiltration of precipitation; the overburden groundwater is not a regional aquifer. As a result, if the Site is capped and infiltration is cutoff, the groundwater table will decline and ultimately the overburden aquifer would be expected to dry out. As a result, in developing costs for this alternative, management of overburden groundwater is included for a period of ten years, which is a reasonable estimate for decline of the overburden groundwater table to the point where it would no longer exist. The estimated flow rate during this time period, is as presented in Section 2.7.2, and is approximately 1.6 gallons per minute. Because the overburden groundwater table is expected to ultimately dry out over time, during the design of the containment components of the remedy, additional evaluations will be conducted to determine the extent to which shallow groundwater collection is actually needed. These evaluations will take into consideration issues such as groundwater outflow through the aquitard, groundwater head buildup during containment component construction, and groundwater flow under the barrier wall. These more detailed evaluations may indicate that it would be possible to collect groundwater either only temporarily or not at all, and still meet the remedy objectives.

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- Excavation and Backfill of Sediments: The sediments located downstream of the pipe bridge culvert across SBC would be removed to the maximum depth of the sediment layer as defined during the RI activities (i.e., 2.5 feet deep). Low marsh soils downstream of the culvert would be removed to a depth of approximately one foot. In addition, the sediments in the Northern Off-Site Ditch would be removed to a depth of approximately 2.2 feet, on average. The excavated sediment and low marsh soil would be consolidated within the upstream portion of the creek. For costing purposes, if has been assumed that 50% of the excavated sediment would not meet LDR requirements and would be treated by ex-situ S/S prior to placement, which would be within a designated CAMU, and would be located within the limits of the Site cap. Additional fill would be placed in the upstream portion of the creek to facilitate incorporation in the overall Site soils remedy and for construction of the cap. It is assumed that, in total, 2 feet of soil would be placed within the upstream portion of South Branch Creek.

- Northern Off-Site Ditch Outlet Extension: The Northern Off-Site Ditch appears to discharge to South Branch Creek east of the culvert bridge crossing which separates the upstream and downstream sections of SBC. Since this alternative involves the backfill of the upstream section of SBC, to facilitate the installation of a soil cap, the existing outlet for the Northern Off-Site Ditch will be extended approximately 250 feet in a culvert to the existing SBC culvert bridge crossing. In doing so, the Northern Off-Site Ditch will continue to discharge to SBC once the upstream section of SBC is backfilled.

- Restore/Mitigate Wetlands along South Branch Creek: The existing wetlands along SBC have been classified an intermediate resource value wetland by NJDEP. During the on-Site habitat assessment conducted as part of the RI, these wetlands were found to be highly degraded and of relatively low habitat quality. Following the remediation of the SBC sediments, the wetlands adjacent to the downstream section of SBC would be restored/mitigated to the extent practicable so that these wetlands are representative of an intermediate resource value wetland. Wetlands disturbed for sediment remediation in the Northern Off-Site Ditch would also be restored/mitigated. Restoration/mitigation of disturbed wetlands would be by the means as previously described in Section 6.

- Building Demolition and On-Site Placement: Demolition of existing buildings and structures would be implemented using standard equipment and practices (explosive demolition would not be used because of the potential for dispersion of mercury) to dismantle the buildings in a controlled manner. Dust control, such as misting, would also be employed during demolition to aid in the control of dispersion of contaminants as the buildings are dismantled. Where visible elemental mercury is observed on the building surfaces, it would be removed to the extent practicable using vacuuming or other similar technique. However, because of the condition of the buildings, personnel would not be permitted to enter the buildings for this purpose. Rather, such activities would only be performed to the extent practicable as the buildings are dismantled. For this alternative, the building slabs are assumed to remain in place, as they would not interfere with remedy implementation, or to the extent that certain portions of slabs interfere with grading or capping only those portions would be removed. Following demolition, steel and other non-porous materials, if any, would be segregated, decontaminated as necessary, and recycled, to the extent practicable. Following removal of surficial visible elemental mercury and segregation of recyclable materials, masonry building debris would be placed on Site under the cap (again a CAMU would be applicable). For the purpose of estimating costs, it is assumed that approximately 25% of the building debris would contain visible elemental mercury, and this portion of the debris would be placed below the sulfur layer of the treatment cap, as an aid in controlling the vaporization of elemental mercury. Because of the presence of contaminants, particularly mercury, in the building materials, processing of the debris would be limited to only that necessary to reduce the size of the material for placement within the soils remedy area. As necessary, voids in larger debris can be "choked off" with smaller debris or soils, so that a suitable subgrade will exist for the final site capping.

- Soil Erosion and Sediment Controls and Site Restoration: Standard soil erosion and sediment control practices typically implemented as part of grading and earthwork projects would be used to limit soil erosion and sediment transport during construction. Surface structures (e.g., perimeter fences) that are to remain but are removed for installation of the cap would be restored, as applicable

- Establish Use Restrictions: Institutional controls in the form of a deed notice and classification exception area (CEA) would be implemented. The deed notice for the site would be established to limit future use because contaminated materials would remain above ARARs, and there would likely be a conservation easement associated with the wetlands restoration/mitigation. In addition, the deed notice would include a description of the engineering controls (site cap, treatment layer, groundwater collection components), along with details on inspection and maintenance requirements of the engineering control necessary to facilitate the long-term effectiveness of the remedy. The CEA would be established for areas where the groundwater contains constituent concentrations above groundwater quality standards. The CEA would be applicable to the overburden groundwater only, as the bedrock groundwater is classified as IIIB, and is not suitable for potable use. Maintenance requirements for the deed notice and the CEA would include a certification component verifying continued effectiveness, per the applicable regulations.

- Monitoring: Groundwater monitoring would be performed to assess the performance of the remedy and is assumed to include both elevation and groundwater quality data. Elevation data would be used to assess continued capture of the bedrock groundwater in the adjacent LPH site system and the performance of the overburden groundwater collection system. Groundwater quality data would be used to assess that the down-gradient bedrock groundwater quality remains consistent with surface water quality criteria, as previously described in Section 6. Typically, groundwater monitoring is performed on a quarterly basis and this is assumed for this site remedy as well, although as data are collected it is not uncommon to decrease the data collection frequency based on consistency of results. Monitoring related to the treatment component of the cap is not anticipated. The treatment layer provides an extra level of mercury vapor control, but the membrane layer of the cap provides the primary mechanism for control of mercury vapor, and monitoring below the cap layer would not be representative of the overall performance of the remedy.
- Miscellaneous: Various miscellaneous activities would be required for the implementation of the this alternative, such as the development and implementation of a health and safety plan, application for required permit equivalents, and obtaining site access as necessary.

A cost estimate for this combined site remedy is presented in Table 7-4. In general, the estimated costs for this alternative are based on the capital costs for site preparation and clearing, treatment cap installation, shallow groundwater collection system installation, excavation of sediments, restoration and mitigation of wetlands, demolition of buildings and other miscellaneous activities. Operation and maintenance costs include site inspections, cap maintenance, groundwater collection and treatment, monitoring, and certifications for institutional/engineering controls that would remain for the Site. The specific cost elements are shown in Table 7-4.

7.2.3 Site Remedy No. 3, Full Containment (Treatment Cap and Barrier Wall)

Site Remedy No. 3 is the same as Alternative No. 2, with the addition of a barrier wall encompassing the site located at the cap perimeter. The components of this remedy are illustrated on Figure 7-2, and include the following:

- Site Preparation and Clearing: Same as Site Remedy No. 2
- Treatment Cap: Same as Site Remedy No. 2
- Barrier Wall: To limit the potential for lateral migration of contaminants, a low-permeability barrier wall would be installed along the limits of the soil cap (~3,900 linear feet) and tie into the top of the glacial till layer (~15-foot average depth). Various alternatives are available for a barrier wall, including sheet piles, slurry wall, membrane wall, and compacted clay. A sheet pile wall (e.g., Waterloo Barrier or equal) was selected over other suitable barrier walls based on installation advantages, less impacted soil management, simplified health and safety during construction, and cost effectiveness. A final decision on the type of barrier wall would be made during remedy design, and selection of an alternative type of wall would not affect the evaluation of this alternative. The LCP Site barrier wall would terminate at the existing LPH site barrier wall at the northern and western edges of the LCP Site boundary. Along the northern LCP property boundary, the existing LPH barrier wall would provide containment for the LCP Site.
- Shallow Groundwater Collection: Same as Site Remedy No. 2
- Excavation and Backfill of Sediments: Same as Site Remedy No. 2
- Northern Off-Site Ditch Outlet Extension: Same as Site Remedy No. 2
- Restore/Mitigate Wetlands Along South Branch Creek: Same as Site Remedy No. 2
- Building Demolition and On-Site Placement: Same as Site Remedy No. 2
- Soil Erosion and Sediment Controls / Site Restoration: Same as Site Remedy No. 2
- Establish Use Restrictions: Same as Site Remedy No. 2
- Monitoring: Same as Site Remedy No. 2
- Miscellaneous: Same as Site Remedy No. 2

A cost estimate for this combined site remedy is presented in Table 7-5. In general, the estimated costs for this alternative are based on the capital costs for site preparation and clearing, treatment cap installation, barrier wall installation, shallow groundwater collection system installation, excavation of sediments, restoration/mitigation of wetlands, demolition of buildings and other miscellaneous activities. Operation and maintenance costs include site inspections, cap maintenance, groundwater collection and treatment, monitoring, and certifications for institutional/engineering controls that would remain for the Site. The specific cost elements are shown in Table 7-5.

7.2.4 Site Remedy No. 4a, Full Containment and Partial Depth Selective Stabilization

Site Remedy No. 4a consists of a full containment remedy, similar to Site Remedy No. 3, with the addition of a treatment component (in situ stabilization with a sulfur compound) for the upper six feet of site soils containing visible elemental mercury and a portion of the building debris. Additionally, due to the excess sulfur material applied during the in-situ stabilization process, there is no need to install a treatment component in the soil cap. The components of this remedy are illustrated on Figure 7-3, and include the following:

- Site Preparation and Clearing: Same as Site Remedy No. 2
- In Situ Stabilization: In situ stabilization would be conducted within the area of soil containing visible elemental mercury (see Figure 7-3), to a maximum depth of six feet. As previously described in Section 2.7.1.2, the preponderance of visible elemental mercury is in the shallow subsurface and the area of visible elemental mercury contains a number of subsurface obstructions and, therefore, presents implementability issues. The six-foot depth limitation focuses on the majority of the visible elemental mercury while reasonably addressing implementation issues. Treatment to the six-foot depth would address approximately 18,100 cubic yards of soil that contains visible elemental mercury . Mixing would be conducted with specialized soil mixing equipment (e.g., large or gang augers) for uniformly mixing the soil and reagent. Soil mixing would be conducted in each sub-area (e.g., 10 foot by 10 foot grid) for a time sufficient to provide for a uniform mixture of soil and reagent. Any increase in soil volume associated with the addition of the stabilization reagents would be graded appropriately to facilitate the installation of the cap. For the purposes of costing this remedy, granular sulfur was selected as the treatment reagent. Research conducted on the formation of metacinnabar through the mixing of elemental mercury and sulfur indicates a typical sulfur loading rate (i.e., reagent addition rate) of 50% weight sulfur per weight mercury (wt/wt mercury). As described in Section 6, an estimate of sulfur loading to allow for the addition of a stoichiometric amount of sulfur would result in a relatively small volume of sulfur per volume of soil. This small volume would limit contact of the sulfur with beads of visible elemental mercury within the soil, resulting in limited conversion

to mercuric sulfide. To allow for the addition of sulfur in such a quantity to result in adequate contact and conversion, the cost for this remedy is represented as a range based on a sulfur loading rate between 5 to 50% wt/wt (i.e., weight sulfur per weight of soil). This range of sulfur loading percentages is typical of empirical data at sites where some form of S/S technology has been applied. The actual mix percentage would have to be determined from treatability studies which would precede final design, if this remedy were selected. In addition, as previously mentioned, treatability studies would investigate the potential for stabilization methods other than sulfur which may be viable at the time treatability studies are conducted, or potentially an equivalent, alternative treatment method, based on technology advances.

Treatability studies, and follow-on pilot studies, as applicable, would also provide a basis for evaluating treatment effectiveness. As described in Section 6, this alternative is designed to provide treatment that could convert elemental mercury to mercuric sulfide, thereby reducing the potential for exposure through the mercury vapor pathway while maintaining low groundwater transport flux because mercuric sulfide is insoluble. Therefore, treatment effectiveness would have two components for bench and pilot-scale evaluation (1) conversion of elemental mercury for reduction of mercury vapor, and (2) reduction of mercury leachability. Both the alternative treatment standards for contaminated soil (40 CFR 268.49) and the CAMU regulations pertaining to treatment requirements (40 CFR 264.552) provide insight to an approach for evaluating treatment effectiveness. Both of the above regulations establish 90% as the minimum treatment efficiency or achieving 10 times the universal treatment standard (UTS) whichever is less stringent. For mercury, the UTS is 0.025 mg/L as measured in TCLP extract, so 10 times the UTS would be 0.25 mg/L in TCLP extract. As a practical matter, however, because the TCLP limit for mercury is 0.2 mg/L for definition as a characteristic hazardous waste, the treatment compliance value becomes 0.2 mg/L (i.e., achieving 0.25 mg/L would redefine the material as hazardous, and cause a repetition of the process).

While there is substantial background to the 90% treatment efficiency, overall the USEPA's goal, as described in the preamble to the CAMU regulations, was to establish treatment standards that "…provide a meaningful level of treatment and be achievable, but should not be so onerous as to discourage cleanup…." USEPA believes that 90% efficiency, at least as a starting point, achieves this goal. The CAMU regulations, however, also include treatment efficiency adjustment factors as follows that can be used on a site-specific basis:

- Technical impracticability which is designed to address the potential that technological infeasibility or inordinate cost would make it impracticable to achieve the minimum treatment standards or any “meaningful treatment at all”.
- Consistency with site cleanup levels, to achieve treatment on par with, for example, soil cleanup criteria.
- Community views to address community concerns such as worker safety, cross-media transfer, and interference with daily activities. Presumably this factor would be addressed during the community involvement process in developing a Record of Decision.
- Short-term risks such as increased exposure during implementation of treatment.
- Engineering design and controls, which permits a reduction in treatment efficiency because of the engineering design of a CAMU (e.g., containment efficiency).

Based on the above, the following treatment effectiveness goals have been established, which would be assessed through treatability and pilot studies:

- 90% conversion of elemental mercury to mercuric sulfide as an initial target. Lower conversion rates would be evaluated in the context of the adjustment factors provided in 40 CFR 264.522, as discussed below.
- Achieving the leachability standard of 0.2 mg/L of mercury in TCLP extract. Because mercury leachability is already low, as described in Section 2, this criterion should also include a statistically meaningful (e.g., 90% confidence level) difference in leachability between pre- and post-treatment testing.
- Also because mercury leachability is already low, as a consequence of attempting to convert elemental mercury to mercuric sulfide, not increasing the leachability of mercury or other contaminants found on site. For example, creating a reducing environment in support of conversion of elemental mercury to mercuric sulfide could cause release of arsenic because of a reduction of iron from the trivalent to divalent form (i.e., arsenic precipitates with ferric iron).
- Finally, because each alternative includes containment that would functionally meet the CAMU design requirements, evaluate the treatment efficiency (i.e., conversion of elemental mercury to mercuric sulfide and mercury leachability) in the context of the adjustment factors provided for

in 40 CFR 264.552. This evaluation should include the practicability, meaningfulness, and short-term risks of treatment (e.g., mercury vapor emissions) , as applicable, by comparison to the containment provided by the other components of the remedy and the risk reduction afforded by the treatment.

Of note, mercury leachability is the subject of on-going research as forms of mercury and pH can have a material impact on leachability. While TCLP testing is the default measure of performance, the CAMU regulations also provide for alternative leachability testing such as SPLP and the leach testing framework developed at Vanderbilt University (Vanderbilt, 2001). The treatability studies should also evaluate leaching test applicability and appropriateness when evaluating treatment effectiveness.

- Soil Cap: The soil cap would be the same as Site Remedy No. 3, except that the treatment layer would not be included, as previously described, because of the excess reagent that would be mixed with soils to treat the upper six feet of the area of soils containing visible elemental mercury.
- Barrier Wall. Same as Site Remedy No. 3
- Shallow Groundwater Collection: Same as Site Remedy No. 2
- Excavation and Backfill of Sediments: Same as Site Remedy No. 2
- Northern Off-Site Ditch Outlet Extension: Same as Site Remedy No. 2
- Restore/Mitigate Wetlands Along South Branch Creek: Same as Site Remedy No. 2
- Building Demolition and On-Site Placement: Demolition of existing buildings and structures and management of the debris would be similar to that described for Site Remedy Nos. 2 and 3, except that for this alternative, building debris that exhibits visible elemental mercury would be stabilized with sulfur, to the extent practicable, prior to placement on Site, consistent with the soils treatment portion of the remedy. For the purpose of estimating costs, it is assumed that approximately 25% of the building debris would contain visible elemental mercury. Because building debris which may contain elemental mercury will essentially be various sized pieces of monolithic material (e.g., masonry), other than potentially evaluating elemental mercury conversion to mercuric sulfide, it is not considered practicable to establish a leachability based treatment standard. However, this should be evaluated further during treatability and pilot studies for the soils component of the remedy. In addition, to implement the soils portion of the remedy, for this alternative the building slabs would also have to be removed

and treated as debris. The extent of pile caps and building piles below the slabs is unknown, and would have to be addressed further during design and implementation. Depending on conditions beneath the slabs, the soil remedy could either work around the piles or it may be necessary to attempt to cutoff piles to the approximate depth of soil treatment. The latter may require partial excavation and an alternative means of treating the soils ex situ or consolidating the material on to an adjacent in-situ treatment cell.

- Soil Erosion and Sediment Controls / Site Restoration. Same as Site Remedy No. 2
- Establish Use Restrictions: Same as Site Remedy No. 2
- Monitoring: Same as Site Remedy No. 2. In addition, it is not anticipated that there would be any additional post-treatment monitoring associated with stabilization of soils and a portion of the building debris.
- Miscellaneous: Same as Site Remedy No. 2

A cost estimate for this combined site remedy is presented in Table 7-6. In general, the estimated costs for this alternative are based on the capital costs for site preparation and clearing, cap installation, barrier wall installation, shallow groundwater collection system installation, in-situ soil stabilization, excavation of sediments, restoration/mitigation of wetlands, demolition of buildings, stabilization of a portion of the building debris, and other miscellaneous activities. Operation and maintenance costs include site inspections, cap maintenance, groundwater collection and treatment, monitoring, and certifications for institutional/engineering controls that would remain for the Site. The specific cost elements are shown in Table 7-6.

7.2.5 Site Remedy No. 4b, Full Containment and Full Depth Selective Stabilization

Site Remedy No. 4b is similar to Site Remedy No. 4a except instead of addressing a depth of six feet for treatment of soil containing visible elemental mercury, in-situ stabilization would be implemented to the maximum depth at which visible elemental mercury was observed during the RI, 17 feet. Similar to that discussed for Site Remedy No. 4a, treatability and pilot studies would be required to evaluate the treatment effectiveness and operational parameters of this remedy. The components of this remedy are illustrated on Figure 7-4, and include the following:

- Site Preparation and Clearing: Same as Site Remedy No. 2
- In Situ Stabilization: Same as Site Remedy No. 4a, except the depth extends beyond six feet, resulting in the treatment of approximately 23,600 cubic yards of soil containing visible elemental mercury.

- Soil Cap: Same as Site Remedy No. 4a
- Barrier Wall: Same Site Remedy No. 3
- Shallow Groundwater Collection: Same as Site Remedy No. 2
- Excavation and Backfill of Sediments: Same as Site Remedy No. 2
- Northern Off-Site Ditch Outlet Extension: Same as Site Remedy No. 2
- Restore/Mitigate Wetlands Along South Branch Creek: Same as Site Remedy No. 2
- Building Demolition and On-Site Placement: Same as Site Remedy No. 4a
- Soil Erosion and Sediment Controls / Site Restoration. Same as Site Remedy No. 2
- Establish Use Restrictions: Same as Site Remedy No. 2
- Monitoring: Same as Site Remedy No. 2
- Miscellaneous: Same as Site Remedy No. 2

A cost estimate for this combined site remedy is presented in Table 7-7. In general, the estimated costs for this alternative are based on the capital costs for site preparation and clearing, cap installation, barrier wall installation, shallow groundwater collection system installation, in-situ soil stabilization, excavation of sediments, restoration/mitigation of wetlands, demolition of buildings, stabilization of a portion of the building debris, and other miscellaneous activities. Operation and maintenance costs include site inspections, cap maintenance, groundwater collection and treatment, monitoring, and certifications for institutional/engineering controls that would remain for the Site. The specific cost elements are shown in Table 7-7.

7.2.6 Site Remedy No. 5a, Full Containment and Partial Depth Selective Excavation and Off-Site Disposal

Site Remedy No. 5a is similar to Site Remedy No. 4a, except instead of treating soils containing visible elemental mercury to a depth of six feet, those same soils would be excavated and disposed of off-site. The components of this remedy are illustrated on Figure 7-5, and include the following:

- Site Preparation and Clearing: Same as Site Remedy No. 2
- Excavation and Off-Site Disposal of Soil with Visible Elemental Mercury: Excavation depth would be to 6 feet below grade, based on the observed locations of visible elemental mercury as shown in the RI, resulting in removal of

approximately 18,100 cubic yards of soil containing visible elemental mercury. Excavation areas would be sloped within acceptable safety limits (i.e., OSHA limits) or appropriate side slope support would be used. As described in Section 6, there is no capacity at currently operating retort facilities to handle the treatment of soils containing visible elemental mercury, which is the required treatment method in accordance with the USEPA's technology-based land disposal restrictions treatment standard for hazardous wastes (which is discussed further in Sections 7.5 and 7.6), as a part of the remedy evaluations. Additionally, there are currently no US based disposal facilities that will accept soil with visible elemental mercury, even if non-hazardous. To date, as of the preparation of this FS, only one facility, USEcology/Stablex of Canada, Inc. has been identified that would accept the excavated soil with visible elemental mercury. For the purposes of costing this remedy, therefore, it has been assumed that the soils would be disposed at the USEcology facility out of the United States in Canada. As discussed further in Sections 7.5 and 7.6, the treatment process for visible elemental mercury impacted soils at the USEcology Stablex facility involves the use of a proprietary S/S technology, which is conducted as a batch method in a "mixing basin". Following solidification of the soil, residual visible elemental mercury not bound within the solidified soil matrix and which remains in the "mixing basin" following the removal of the solidified soil would be collected and retorted. The costs for this remedy are represented as a range based on this potential for retorting, assuming that between 0 to 10% of the soil to be disposed of off-site would require retorting following the USEcology/Stablex S/S implementation. Under the provisions of the Mercury Export Ban Act, which would be in effect at the time the remedy is implemented, if a portion of the waste is subjected to retorting, recovered mercury would have to remain in or be returned to the US. Final disposition would have to be determined at the time of the work, but it is possible that the mercury would be returned to the Site and/or implementing party. Based on the areas and volumes of media calculations presented in Section 2.7, approximately 77% of the total estimated quantity of soils present at the Site with visible elemental mercury would be removed through implementation of this remedy (to the 6 foot depth).

- Post-Excavation Confirmatory Sampling: The post-excavation sampling component of this alternative would be designed to confirm that at the lateral limits of excavation the soils no longer exhibit the presence of visible elemental mercury. Sampling activities would involve both collection of excavation sidewall samples for visual analysis and direct observation of the excavation sidewall for the occurrence of visible elemental mercury. Excavation sidewall samples would also be tested for the presence of visible elemental mercury utilizing a headspace analysis for volatile mercury testing method. If additional visible elemental mercury is identified along the limits of the excavation side slope, soil within that area would be removed until elemental mercury is no longer observed. Post-excavation samples would be located in a manner generally consistent with the NJDEP *Technical Requirements for Site Remediation*, or other relevant technical guidance at the time the work is performed.

- Backfill: Following the completion of the post-excavation confirmatory samples, the excavation areas would be backfilled with appropriate fill (e.g., clean or a beneficial reuse material, as contaminants will remain on Site), and graded as appropriate for the installation of the soil cap.
- Treatment Cap: Same as Site Remedy No. 2. Since this excavation alternative leaves soils which contain visible elemental mercury, albeit at a depth of six feet, the treatment component of the cap is included as an additional measure of mercury vapor control.
- Barrier Wall: Same as Site Remedy No. 3
- Shallow Groundwater Collection: Same as Site Remedy No. 2
- Excavation and Backfill of Sediments: Same as Site Remedy No. 2
- Northern Off-Site Ditch Outlet Extension: Same as Site Remedy No. 2
- Restore/Mitigate Wetlands Along South Branch Creek: Same as Site Remedy No. 2
- Building Demolition and Placement On-Site / Off-Site Disposal: Demolition of existing buildings and structures would be the same as described for Site Remedy No. 4a, with the addition of disposal of a portion of the building debris off Site. For the purpose of estimating costs, it is assumed that approximately 25% of the building debris contains visible elemental mercury and would be disposed off-Site as hazardous (i.e., at the USEcology facility in Canada). Prior to disposal, building debris would be crushed to a suitable size for disposal, and appropriate vapor and dust controls would be incorporated. However, for the purpose of this alternative costing, the assumption has been made that the demolition crushing would not need to occur inside of an enclosure. However, if this alternative were selected, the need for an enclosure would be further evaluated during pre-design studies and design.
- Treatment Cap: Same as Site Remedy No. 2
- Barrier Wall: Same as Site Remedy No. 3

- Shallow Groundwater Collection: Same as Site Remedy No. 2
- Excavation and Backfill of South Branch Creek: Same as Site Remedy No. 2
- Restore/Mitigate Wetlands Along South Branch Creek: Same as Site Remedy No. 2
- Soil Erosion and Sediment Controls / Site Restoration: Same as Site Remedy No. 2
- Establish Use Restrictions: Same as Site Remedy No. 2
- Monitoring: Same as Site Remedy No. 2
- Miscellaneous: Same as Site Remedy No. 2

A cost estimate for this combined site remedy is presented in Table 7-8. The estimated costs for this alternative are based on the capital costs for site preparation and clearing, excavation and off-Site disposal, backfill, post-excavation confirmatory sampling, treatment cap installation, barrier wall installation, shallow groundwater collection system installation, excavation of sediments, restoration/mitigation of wetlands, demolition of buildings and disposal of a portion of the debris off Site, and other miscellaneous activities. Operation and maintenance costs include site inspections, cap maintenance, groundwater collection and treatment, monitoring, and annual certifications for institutional/engineering controls that would remain for the Site. The specific cost elements are shown in Table 7-8.

7.2.7 Site Remedy No. 5b, Full Containment and Full Depth Selective Excavation and Off-Site Disposal

Site Remedy No. 5b is similar to Site Remedy No. 5a except instead of addressing a depth of six feet for removal of soil containing visible elemental mercury, excavation of soils containing visible elemental mercury would be performed to the maximum depth at which visible elemental mercury was observed during the RI, 17 feet. As this remedy would result in the removal of soil with visible elemental mercury, the treatment component of the cap would not be included. The components of this remedy are illustrated on Figure 7-6, and include the following:

- Site Preparation and Clearing: Same as Site Remedy No. 2
- Excavation and Off-Site Disposal of Soil Containing Visible Elemental Mercury: This component of the remedy is similar to Site Remedy No. 5a, except that excavation would be based on the observed locations of visible elemental mercury documented in the RI, and based on these data the maximum excavation depth is

estimated at 17 feet. This would result in an estimated excavation volume of 23,600 cubic yards of soil containing visible elemental mercury.

- Post-Excavation Confirmatory Sampling: Post-excavation confirmatory sampling would be conducted similar to that described for Site Remedy No. 5a, with the addition of sampling in the excavation bottom to confirm the base of the excavation has also had the visible elemental mercury removed as well as the along the lateral extents.
- Backfill: Same as Site Remedy No. 5a
- Soil Cap: Same as Site Remedy No. 4a
- Barrier Wall: Same as Site Remedy No. 3
- Shallow Groundwater Collection: Same as Site Remedy No. 2
- Excavation and Backfill of Sediments: Same as Site Remedy No. 2
- Northern Off-Site Ditch Outlet Extension: Same as Site Remedy No. 2
- Restore/Mitigate Wetlands Along South Branch Creek: Same as Site Remedy No. 2
- Building Demolition and Placement On-Site / Off-Site Disposal: Same as Site Remedy No. 5a
- Soil Erosion and Sediment Controls / Site Restoration: Same as Site Remedy No. 2
- Establish Use Restrictions: Same as Site Remedy No. 2
- Monitoring: Same as Site Remedy No. 2
- Miscellaneous: Same as Site Remedy No. 2

A cost estimate for this combined site remedy is presented in Table 7-9. The estimated costs for this alternative are based on the capital costs for site preparation and clearing, excavation and off-Site disposal, backfill, post-excavation confirmatory sampling, cap installation, barrier wall installation, shallow groundwater collection system installation, excavation of sediments, restoration/mitigation of wetlands, demolition of buildings and disposal of a portion of the debris off Site, and other miscellaneous activities. Operation and maintenance costs include site inspections, cap maintenance, groundwater collection and treatment, monitoring, and annual certifications for institutional/engineering controls that would remain for the Site. The specific cost elements are shown in Table 7-9.

7.3 Evaluation Criteria

The site remedies developed from the alternative screening process, as described above, were analyzed by comparison to seven of the nine evaluation criteria established in EPA as described in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, which include:

- Threshold Criteria: These criteria must be met by a particular site remedy for it to be eligible for selection as a remedial action and include the following individual criteria:
    - Overall protection of human health and the environment: This criterion assesses the overall performance of a remedy in protecting human health and the environment by evaluation of the remedy's ability to meet the remedial action objectives, the efficacy of the remedy, and its ability to control or eliminate the potential risk pathways (e.g., direct contact with soils).
    - Compliance with applicable or relevant and appropriate requirements (ARARs): This criterion is used to establish whether a remedy complies with applicable or relevant and appropriate environmental laws, regulations, standards, and guidance. This criterion also reviews the relative permitting requirements applicable to the remedy.
- Balancing Criteria: These criteria are used to compare trade-offs between site remedies and include the following individual criteria:
    - Long-term effectiveness and permanence: This criterion is used to assess how the remedy is expected to perform over the long-term and whether the remedy is permanent. In addition, this criterion deals with the magnitude of the remaining risk and ability of the remedy to meet remedial action objectives in the future if contaminants remain on-site after implementation of the remedy.
    - Reduction of toxicity, mobility or volume: This criterion is used to assess how the remedy reduces the toxicity, mobility, or volume of site-related constituents (e.g., visible elemental mercury) through removal and or treatment.
    - Short-term effectiveness: This criterion is used to evaluate the implementation related impacts of a remedy, safety, and the remedy's protectiveness related to the community, the workers, and the environment during the short-term implementation period. In addition, this criterion is

used to evaluate the length of the time required for the remedy to meet remedial action objectives.

- Implementability: This criterion is used to evaluate the availability of equipment, materials, and methods associated with a remedy and the practicability of implementing the remedy.
- Cost: This criterion provides an overall estimate of the capital, operation, maintenance, and monitoring costs associated with a remedy, for comparison to the remedy's expected performance and to other remedies. Present worth costs are calculated for each remedy using a discount rate of seven percent (the USEPA default guidance value) and a planning horizon of 30 years. Cost estimates are typically evaluated on an accuracy of +50%/-30%.

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- Modifying Criteria: In addition to the above seven criteria, two additional evaluation criteria exist: (1) community acceptance, and (2) state acceptance. These criteria are evaluated after the feasibility study as a part of the process of developing a proposed remedial action plan and issuing a Record of Decision (ROD). Typically the USEPA will collect the input regarding these criteria through its role as the lead agency and coordination with the NJDEP, and through the public participation portion of the ROD process. Consequently, these criteria are not evaluated further in this FS.

7.4 Additional Considerations for Evaluation of Site Remedies

7.4.1 Mercury Vapor Emissions

Elemental mercury is susceptible to volatilization due to its relatively high vapor pressure, at least by comparison to other metals, although much less than volatile organic compounds. Mercury vapors have been detected in soil gas samples collected at some locations on the site, and elemental mercury has been observed in some of the Site soils, as previously described. As such mercury vapor is an important issue in evaluating site remedies.

The rate at which mercury volatilizes from the soil can be affected by activities that disturb or expose the elemental mercury. For example, disturbance of visible elemental mercury in the Site soils during excavation activities could result in an increase in mercury emissions compared to pre-remedy implementation conditions. To properly apply the previously described evaluation criteria, particularly as it relates to criteria such as short-term effectiveness and implementability, a consistent means of evaluating the potential implications of remedy implementation on mercury vapor emissions is necessary. The following section provides the basis for evaluation of mercury vapor emission rates for the Site and estimated emissions for the various remedies. This method of estimating mercury vapor emissions is then used to compare the relative differences in mercury emissions between the Site remedies as part of the comparative analysis presented in Section 7.6.

The majority of known visible elemental mercury is contained within the site soils (some visible elemental mercury is evidenced in building materials but this is a much smaller quantity). The soil component of the site remedies is of a much larger scale than the other media components, and except for minor variations, site remedies are similar except for the soil portion. As a consequence, mercury vapor emission estimates for use in site remedy comparisons is based on the soils that contain visible elemental mercury. In doing so, a relative comparison of mercury emissions can be established between the different site remedies.

As previously discussed in Section 2, four soil vapor samples collected during the RI indicated that mercury vapor was present in the Site soils, with concentrations between 0.2 to 2.5 ug/m^3. These soil vapor samples were collected from areas outside of the area of visible elemental mercury, as shown on Figures 2-5 and 2-6. Therefore, it is possible that mercury soil vapor concentrations within the area of visible elemental mercury could be greater than those measured during the RI, but nonetheless the RI provides some quantitative data. Of note, these concentrations are within soil vapor, not in the ambient air. The quarterly building observation and air monitoring at the Site has consistently documented that concentrations of mercury in air at the Site are within the limits established for this monitoring program, and there is no indication of the presence of mercury vapors in ambient air leaving the Site.

Soil vapor measurements taken during the RI represent the concentration of mercury vapor within the soil pore space and not a rate at which mercury soil vapor is being emitted from the site soils. As a first step to estimating a mercury vapor emission rate, or flux, from the LCP Site, a literature review was conducted to understand typical mercury emission rates from sites with mercury contaminated soil. From this review, for sites with mercury soil concentrations up to 150 mg/kg, mercury emission rates ranged from 0 – 3 ug/m^2-min (measurements taken at various ambient temperatures). Details on these sites are presented in Appendix E. The occurrence of visible elemental mercury was not specifically mentioned for these sites, which if present, could result in an increased mercury flux. Additionally, in comparison to the maximum 150 mg/kg mercury soil concentration observed in the literature review, the average mercury soil concentration in the area of observed visible elemental mercury at the LCP Site is approximately 2,065 mg/kg (Appendix F).

Another example data source for mercury vapor emissions from soil is from a former chlor-alkali facility which is currently being remediated (Orica, Botany, Australia site). Mercury vapor emissions were measured from site soils, which contained both total mercury concentrations up to approximately 3,000 mg/kg and evidence of visible elemental mercury, either within the site soils or on the surface of the site soils, which is similar to the conditions observed at the LCP Site. Mercury vapor emissions were measured at the Orica site between 0 and 140 ug/m^2-min, with a site average of 47 ug/m^2-min. For consistency purposes, all mercury emission measurements were temperature corrected to 25^{o}C.

A third source of data regarding mercury vapor emissions is the Ventron/Velsicol Superfund site. At this site a soil remediation was performed that included excavation and off-site disposal of soils contaminated with mercury, and in some instances containing visible elemental mercury. Concentrations of mercury in the soil remediation area ranged from a 1,000 to 10,000 mg/kg (Personal Communication, Parsons, February 2011), so in a range similar to the LCP Site. Emissions testing was performed as a part of the evaluation of mercury vapor suppression methods. Specifically, mercury vapor suppression testing included vapor emissions measurements from three pilot plots of five feet square each, and then during a subsequent phase of testing from a plot measuring 20 feet square. The mean breathing zone mercury air concentrations from the three 25 square-foot plots ranged from 1.2 to 66.5 ug/m^3 and from the 400 square-foot plot measured 21 ug/m^3. Using the USEPA's Soil Screening Guidance (USEPA 1996) calculation method for estimating outdoor air concentrations (see calculations in Appendix F), for a breathing zone concentration of 21 ug/m^3, the resultant calculated flux from a 400 square foot area is 151 ug/m^2-min. This value is in a range similar to that found at the Botany, Australia site as described above, where higher concentrations of mercury were present in soils.

Utilizing the above range of mercury soil emission rates as guidance, emission rates were estimated for the LCP Site utilizing soil gas diffusion equations adopted from the Johnson and Ettinger model. Details on these calculations are shown in Appendix F. Mercury vapor emissions from the Site soils where calculated using the following assumptions:

- Vapor phase concentrations within the soil air voids calculated as a function of soil mercury concentration. Typically, modeling emission of a volatile source takes into consideration a saturated vapor phase concentration. A saturated vapor phase concentration represents an upper limit which cannot be exceeded even with increasing soil concentrations and has been calculated based on the equilibrium soil gas concentration that would exist due to the presence of visible elemental mercury within the soil. Observations of measured elemental mercury emission rates at the Orica site suggest that the use of a saturated vapor phase concentration is not applicable to visible elemental mercury. A number of measured emission rates at the Orica site, mostly in areas where visible elemental mercury was observed, exceeded the model emission rates that assumed a saturated vapor phase concentration. When this upper limit was not included in the calculation, modeled emission rates were more consistent with measured emission rates. The average mercury soil concentration was used in the emission calculations presented herein, which in the area of observed visible elemental mercury at the LCP Site is approximately 2,065 mg/kg.

- Visible elemental mercury is located near the soil surface (15 cm), which is consistent with observations of mercury occurring near and on the surface of the Site soils. The area of visible elemental mercury is as shown on Figure 7-3 and is approximately 90,300 square feet.
- Physical parameters for mercury were taken from various EPA and National Institute of Standards (NIST) references.
- Due to the exponential temperature dependency of the vapor pressure of mercury, mercury emissions increase with increasing ambient temperatures. The emission calculations were performed at a range of temperatures between 0°C to 40°C (32°F to 100°F), representative of typical and even conservatively high temperatures found at the LCP Site. At temperatures below 0°C, due to the low vapor pressure of mercury, mercury vapor emissions would not be expected to be significant.

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Based on the mercury vapor calculations presented in Appendix F, the following mercury vapor emissions rates were estimated for the area of soils containing visible elemental mercury:

Temperature (°C)	Mercury Emission Rate (ug/m^2-min)
0	8.1
10	23
20	59
30	143
40	328

This is not to suggest these are actual mercury emissions rates. Rather, these values are comparable to those measured at the Orica site and estimated from the Ventron/Velsicol site data, both of which have mercury soil contamination similar to the LCP site (i.e., similar range of soil concentrations, evidence of visible elemental mercury), and therefore, indicate that the calculation method is useful for comparing emissions rates for the various alternatives. These estimated emission rates will be utilized as a baseline to provide a relative comparison of mercury emission increases associated with the implementation of the various site remedies.

To estimate potential increases above the baseline mercury emission rate which could occur during various construction activities required for the implementation of the combined site remedies, the following assumptions for various soil remedy construction activities were made:

- Earthmoving: Mercury Emissions 5x Baseline Conditions: Earthmoving activities represent the greatest potential for an increase in mercury vapor emissions from the Site, primarily due to disturbing the visible elemental mercury contained within the soils. Data obtained from a study of agricultural field operations (i.e., tilling) indicates that mercury emissions could increase up to 4 times background concentrations (Bash and Miller, 2007). In addition, data from the Ventron/Velsicol mercury vapor suppression study (using the product HgX®) indicates that during excavation operations, downwind mercury concentrations could increase 4 to 6 times upwind concentrations (Parsons 2009). For the purposes of this FS, mercury emissions from earthmoving activities (i.e., grading and excavation) are assumed to be 5 times estimated baseline conditions.
- Stockpiled Soil: Mercury Emissions 2x Baseline Conditions: It is assumed that stockpiled soil which contains visible elemental mercury will either be covered with a suitable material (e.g., tarp, foam) to control mercury vapor emissions or treated with a complexation/sequestering agent, such as HgX® (i.e., sulfur based spray applied liquid) to minimize mercury vapor emissions. As such, it is assumed that only a slight increase of 2 times the baseline mercury emissions would result from the stockpile of soil containing visible elemental mercury.
- In-Situ Stabilization: Mercury Emissions 2x Baseline Conditions: While in-situ stabilization represents, to some degree, an earthmoving activity, various laboratory stabilization studies on the room temperature mixing of sulfur and elemental mercury indicate that minimal mercury vapors are generated during the process. Some testing has indicated that the headspace directly above a mixing vessel during the sulfur stabilization process is below the OSHA 8-hour worker

exposure limit of 50 ug/m^3 to as low as 8 ug/m^3 (USDOE 1999, Mattus 2001, Gorin et al. 1998). For comparison, the saturated vapor phase concentration of mercury used for the baseline emission calculation described above is approximately 14,000 ug/m^3. Given this observation and that a relatively long mixing process will be required for adequate contact between the sulfur and visible elemental mercury, it is assumed that only a slight increase of 2 times the baseline mercury emissions would result from the in-situ stabilization process. In addition, as described above in Section 7.2, an excess of sulfur would be applied during the stabilization process. This excess sulfur would help to limit mercury vapor emissions in areas of the site where in-situ stabilization activities have been completed.

The above baseline mercury vapor emission estimates and modification factors for various soil remedy implementation activities were used to estimate a total mercury vapor emission during the course of the soil remedy implementation. Details of these calculations are shown in Appendix F and are summarized on Table 7-2b as part of the site remedy analysis.

7.4.2 Stabilization Treatment Efficiency

7.4.2.1 In-Situ Stabilization

Various research studies have shown that elemental mercury can be converted to metacinnabar without the application of heat (i.e., at room temperature) (Svenson et al., Lopez et al., USDOE). These studies indicate conversion may be achievable within the LCP Site soils, although no such information currently exists to examine the overall outcome of applying such a technology under conditions such as at the LCP Site. While treatability and likely pilot studies will be required to implement an in-situ stabilization remedy to determine various operating parameters (i.e., sulfur loading rate, sulfur type, mixing type/rate, etc.) and remediation goals (i.e., percent elemental mercury conversion), to facilitate the comparative analysis of the site remedies, an in-situ stabilization treatment process and overall conversion efficiency were developed based on the current knowledge of elemental mercury stabilization by sulfur, which can be summarized as follows:

- Powdered sulfur and elemental mercury in a well mixed vial at stoichiometric conditions: Under anaerobic and aerobic dry conditions (only sulfur and mercury in vial), conversion efficiencies in the range of 20% were achieved over a storage period of three years. Minimal mixing of the vials was conducted during the three year storage period. Under aerobic wet alkaline conditions (equal quantity water added to vial), a conversion efficiency of 25% was achieved over the same three year time period. Under anaerobic wet alkaline conditions, 80% conversion was achieved. Svenson 2006.

- Powdered sulfur and elemental mercury in pugmill: Sulfur and elemental mercury were combined in a pugmill at a sulfur loading of 43% by weight at room temperature, resulting in a conversion efficiency of 50%. Using a proprietary additive mixture, the conversion efficiency increased to 98.8%, although TCLP results were between 1.2 to 2.6 mg/L. Sand was added to the test, allowing for beads of elemental mercury to be broken up into smaller beads, yielding a larger surface area to react with the sulfur. The addition of sand resulted in a 99.9% conversion and TCLP results of 0.1 mg/L. USDOE 1999.
- 60 mesh sieve size sulfur and elemental mercury in a paint shaker with milling balls: Sulfur and elemental mercury combined in a paint shaker with 7/16 inch milling balls for a period of 2 hours at room temperature. The use of milling balls has a similar effect as sand, allowing for the breakup of the beads of mercury to provide a large surface area to react with the sulfur. At a sulfur loading rate of 50% by weight, a conversion efficiency of 99% was achieved. Gorin et al 1994.
- Powdered sulfur and elemental mercury in a ball mill: Sulfur and elemental mercury were combined at a sulfur loading rate of 50% by weight in a ball mill at room temperature for up to 90 minutes. During milling, the temperature increased up to a maximum of 45^{o}C. It is hypothesized that this increase in temperature facilitated the formation of mercuric sulfide. Unreacted elemental mercury was observed for milling times less than 60 minutes. Lopez et al 2008.

Based on the above data regarding conversion of elemental mercury to mercuric sulfide, the following operational parameters have been assumed for the proposed in-situ stabilization process for the LCP Site soils to facilitate a comparative analysis to other remedies:

- In-situ mixing will be conducted in a 10' x 10' grid for a time period of 90 minutes to allow for contact (i.e., reaction) of sulfur with the visible elemental mercury. The presence of soil should produce an effect similar to milling balls or sand that was used in the bench scale experiments described above. The mixing time should allow for contact between the sulfur and elemental mercury.
- Due to the fact that the visible elemental mercury is contained within the site soils, these soils will act to limit contact of the sulfur and elemental mercury particularly given the heterogeneous nature of the fill found on the Site. In addition, the soil will also limit potential heat that may be generated in the process, further limiting the treatment efficiency. The occurrence of a relatively shallow groundwater table, approximately 6 feet deep, portions of the in-situ

stabilization process may occur in a saturated zone, potentially further limiting treatment efficiency. Collectively considering these factors, it is assumed that the treatment efficiency of the in-situ stabilization method is 75%.

7.4.2.2 Treatment Cap Efficiency

As previously described, to control the potential for mercury vapor accumulation below the soil cap, for the treatment cap component of the combined Site remedies, a layer of sulfur would be placed as the bottom most layer of the cap to provide for the conversion of mercury vapors to mercuric sulfide. For the purposes of quantifying the conversion of mercury vapors to mercuric sulfide for comparison with the other soil remedies, an estimate of mercury vapor emission from the soil below the cap was calculated based on the methods discussed in Section 7.4.1, with a modification to the temperature component of the calculation. The soil cap will be approximately 24 inches thick, and as a result the ambient soil temperature will most likely be held relatively constant throughout the year and not be affected by large shifts in ambient atmospheric temperature. Therefore, for the mercury vapor flux estimate from the underlying soil into the treatment cap, a temperature of $13^{o}C$ ($55^{o}F$) was assumed.

Details on the calculation of mercury vapor flux into the treatment cap are presented in Appendix F and result in a mercury vapor flux estimate of 5.8 ug/m^2-min. Over the area of visible elemental mercury where the treatment cap will be placed (~90,300 square feet), as shown on Figure 7-1, approximately 57 pounds of mercury vapor would be treated per year.

7.5 Detailed Evaluation of Site Remedies

A summary of the evaluation of the site remedies against the seven criteria described in Section 7.3 is presented in Tables 7-2a and 7-2b. The results of this evaluation are discussed in the Sections that follow.

7.5.1 Site Remedy No. 1 – No Action

This site remedy was retained as a baseline for comparison with other alternatives and evaluation against the seven criteria is as follows:

- Protection of Human Health and the Environment
    - Not protective of human health or the environment
    - Does not meet RAOs for the Site
- Compliance with ARARs

- o Does not meet requirements of ARARs
- Long-Term Effectiveness
  - o Not effective
- Reduction of Toxicity, Mobility, or Volume
  - o No reduction of toxicity, mobility or volume
- Short-Term Effectiveness
  - o No remedial or construction activities occur, therefore no short-term impacts associated with implementation
- Implementability
  - o Readily implementable
- Cost
  - o No associated cost

7.5.2 Site Remedy No. 2 – Partial Containment (Treatment Cap)

Deleted: This site remedy was retained as a baseline for comparison with other alternatives. It would not be protective of human health or the environment, and would not meet the RAOs for the Site. Site Remedy No. 1 would not reduce toxicity, mobility or volume of contamination nor would it meet ARARs. Because no remedial or construction actions are taken, there would not be short-term impacts from implementation. While it is readily implementable and has no associated costs, this site remedy remains only as a benchmark for comparison of other site remedies.¶

Evaluation of the partial containment alternative against the seven criteria is summarized as follows:

- Protection of Human Health and the Environment
  - o The remedy would be protective of human health and the environment through containment.
  - o Remedy would meet the RAOs, as follows:
    - Direct contact exposure pathways for both COPCs related to site operations and COPCs related to anthropogenic fill would be eliminated through the implementation of a soil cap, shallow groundwater collection system and removal and on-site placement of contaminated sediments.
    - Overburden groundwater would be extracted and treated so that migration would be controlled. It is unlikely that applicable groundwater standards would be achieved (see Table 2-1 for constituents above groundwater standards) before the overburden groundwater table has fully dissipated as a result of cutting off infiltration, as the groundwater is contained within the anthropogenic fill. However, in accordance with USEPA *Guidance on Remedial Actions for Contaminated Ground Water at*

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Superfund Sites, because "waste" material would remain in place, the area of attainment of cleanup levels is outside the boundary of remaining waste or in this case would be outside the boundary of the cap.

- The buildings would be demolished and the debris properly managed on Site thereby minimizing the potential for exposure and eliminating safety hazards.
- Mercury inhalation exposure pathway would be eliminated though the implementation of a soil cap with a geomembrane.
- The treatment component of the soil cap would further limit the potential for exposure to mercury vapor by reducing the potential for the accumulation of mercury vapor below the cap.

- Compliance with ARARs
  - The remedy would comply with ARARs to the extent practicable.
  - To implement the remedy would likely require regulatory approvals (e.g., permit equivalents) for NJPDES, waterfront development, work in wetlands, fill in a floodplain, groundwater and soil remediation (new NJ SRRA requirements), a CAMU or designation as a solid waste management unit for long-term storage of contaminated media below the soil cap, work in a regulated waterway, and stormwater pollution prevention. None of these approvals would be out of the ordinary for the remedy implementation components, and should be acquired.
  - Soils above relevant cleanup criteria (i.e., the NJ soil remediation standards) would be addressed.
  - Overburden groundwater with concentrations of contaminants above relevant criteria (i.e., NJ groundwater quality criteria or MCLs) would be contained; however, as noted above, achieving these criteria would likely not occur before the overburden groundwater table has fully dissipated as a result of cutting off infiltration because the overburden groundwater is contained within the anthropogenic fill, and the area of attainment would not include the containment boundaries per se, which for all intents and purposes would be the overburden groundwater zone. For the purpose of this FS, the decline of the overburden groundwater is assumed to occur over a period of approximately 10 years.
  - The restored portion of South Branch Creek would achieve applicable guidelines for sediment quality criteria or alternative cleanup levels

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consistent with "background" levels in the Arthur Kill, as described in Section 6.

- Long-Term Effectiveness
  - The remedy would be effective in the long term with proper maintenance of the soil cap.
  - The soil cap components have an unlimited lifespan, being natural materials. Geosynthetic components have typical lives in the hundreds of years, well beyond the typical planning horizon for an FS under CERCLA (i.e., 30 years).
- Reduction of Toxicity, Mobility, or Volume
  - Remedy will reduce the mobility of site contamination through control of groundwater and limiting mercury vapor movement.
  - A reduction in the volume of elemental mercury would be achieved through the treatment of mercury vapors (approximately 57 pounds per year converted to mercuric sulfide). The total quantity of mercury at the Site would not be altered, just the form
- Short-Term Effectiveness
  - Short term construction impacts would exist including traffic and noise (albeit not out of the ordinary given the industrial character of the area), dust, and the potential for a short-term increase in mercury vapor emissions due to construction activities.
  - Based on the estimated implementation period for this remedy (~1-2 years), during which some incremental disturbance would occur (e.g., miscellaneous grading), the incremental estimated mercury vapor emissions are calculated at 7.7 pounds during remedy implementation using the 2x above baseline factor previously described (See Appendix F for calculations).
  - Construction and health and safety controls would have to be in place during implementation to limit the potential impacts to human health and environment.
- Implementability
  - Remedy implementation activities (i.e., grading, excavation, backfill, building demolition) are implementable with conventional equipment and materials

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- Cost (30 Year Net Present Worth)
  - The total estimated cost for this remedy, including 30 years of routine operation and maintenance is $20,960,000. Table 7-4 presents additional detail on the basis for this cost.

7.5.3 Site Remedy No. 3 – Full Containment (Treatment Cap and Barrier Wall)

Evaluation of the full containment alternative against the seven criteria is summarized as follows:

- Protection of Human Health and the Environment
  - This remedy is similar to No. 2 and would also be protective of human health and the environment through containment, with the addition of a barrier wall.
  - The remedy would meet the RAOs, as follows:
    - Direct contact exposure pathways for both COPCs related to site operations and COPCs related to anthropogenic fill would be eliminated through the implementation of a soil cap, barrier wall, shallow groundwater collection system and removal and on-site placement of contaminated sediments.
    - Overburden groundwater would be extracted and treated so that migration would be controlled. The barrier wall also provides a physical barrier to lateral migration. It is unlikely that applicable groundwater standards would be achieved before the overburden groundwater table has fully dissipated as a result of cutting off infiltration, as the groundwater is contained within the anthropogenic fill. However, in accordance with USEPA *Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites*, because "waste" material would remain in place, the area of attainment of cleanup levels is outside the boundary of remaining waste or in this case would be outside the boundary of the barrier wall and cap. For the purpose of this FS, the decline of the overburden groundwater is assumed to occur over a period of approximately 10 years.
    - The buildings would be demolished and the debris properly managed on Site thereby minimizing the potential for exposure and eliminating safety hazards.

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Moved up [4]: Short term construction impacts including traffic and noise (albeit not out of the ordinary given the industrial character of the area), dust, and the potential for a short-term increase in mercury vapor emissions due to construction activities. Based on the estimated implementation period for this remedy (~1-2 years), during which some incremental disturbance would occur (e.g., miscellaneous grading), the incremental estimated mercury vapor emissions are calculated at 7.7 pounds during remedy implementation using the 2x

Deleted: This site remedy would be protective of human health and the environment through containment. This remedy would meet the RAOs as follows:¶
<#>Direct contact exposure pathways would be eliminated through the implementation of a soil cap, shallow groundwater collection system and removal and on-site placement of contaminated sediments.¶
<#>Overburden groundwater would be extracted and treated so that migration would be controlled. It is unlikely that applicable groundwater standards would be achieved (see Table 2-1 for constituents about groundwater standards) before the overburden groundwater table has fully dissipated as a result of cutting off infiltration, as the groundwater is contained within the anthropogenic fill.¶
<#>The buildings would be demolished and the debris properly managed on Site thereby minimizing the potential for exposure and eliminating safety hazards.¶
In addition to the above, the mercury inhalation exposure pathway would be eliminated though the implementation of a soil cap. Also, the treatment component of the soil cap would further limit the potential for exposure to mercury vapor by reducing the potential for the accumulation of mercury vapor below the cap. ¶
This site remedy would comply with ARARs to the extent practicable, as follows:¶
<#>To implement the remedy would likely require regulatory approvals (e.g., permit equivalents) for NJPDES, waterfront development, work in wetlands, fill in a floodplain, groundwater and soil remediation (new NJ SRRA requirements), a CAMU for lo ...

Moved up [2]: <#>To implement the remedy require regulatory approvals (e.g., permit equivalents) for NJPDES, waterfront development, work in wetlands, fill in a floodplain, groundwater and soil remediation (new NJ SRRA requirements), a CAMU for long-term storage of contaminated media below the soil cap, work in a regulated waterway, and stormwater pollution prevention. None of these approvals would be out of the ordinary for the remedy implementation components, and should be acquired.¶ ...

Moved up [3]: Remedy implementation activities (i.e., grading, excavation, backfill, building demolition) are implementable with conventional equipment and materials

- The mercury inhalation exposure pathway would be eliminated though the implementation of a soil cap, and to the extent that mercury vapor has the potential to move laterally, it would be impeded by the barrier wall.

- The treatment component of the soil cap would further limit the potential for exposure to mercury vapor by reducing the potential for the accumulation of mercury vapor below the cap.

- Compliance with ARARs
  - The remedy would comply with ARARs to the extent practicable.
  - To implement the remedy would likely require regulatory approvals (e.g., permit equivalents) for NJPDES, waterfront development, work in wetlands, fill in a floodplain, groundwater and soil remediation (new NJ SRRA requirements), a CAMU or designation as a solid waste management unit for long-term storage of contaminated media below the soil cap, work in a regulated waterway, and stormwater pollution prevention. None of these approvals would be out of the ordinary for the remedy implementation components, and should be acquired.
  - Soils above relevant cleanup criteria (i.e., the NJ soil remediation standards) would be addressed.
  - Overburden groundwater with concentrations of contaminants above relevant criteria (i.e., NJ groundwater quality criteria or MCLs) would be contained; however, as noted above, achieving these standards would likely not occur before the overburden groundwater table has fully dissipated as a result of cutting off infiltration because the overburden groundwater is contained within the anthropogenic fill, and the area of attainment would not include the containment boundaries per se, which for all intents and purposes would be the overburden groundwater zone.
  - The restored portion of South Branch Creek would achieve applicable guidelines for sediment quality criteria or alternative cleanup levels consistent with “background” levels in the Arthur Kill, as described in Section 6.

- Long-Term Effectiveness
  - The remedy would be effective in the long term with proper maintenance of the soil cap.

  - The soil cap components have an unlimited lifespan, being natural materials. Geosynthetic components have typical lives in the hundreds of years, well beyond the typical planning horizon for an FS under CERCLA (i.e., 30 years). The barrier wall does not require maintenance to remain effective, and would typically have a life span in the range of 100 – 200 years, again well beyond the typical planning horizon for an FS.

- Reduction of Toxicity, Mobility, or Volume
  - The remedy will reduce the mobility of site contamination through control of groundwater, control of mercury vapor movement, and construction of the barrier wall.
  - A reduction in the volume of elemental mercury would be achieved through the treatment of mercury vapors (approximately 57 pounds per year converted to mercuric sulfide). However, the total mass of mercury present on Site would be unchanged, only the form would be altered.

- Short-Term Effectiveness
  - Short term construction impacts would exist including traffic and noise (albeit not out of the ordinary given the industrial character of the area), dust, and the potential for an increase in mercury vapor emissions due to construction activities.
  - Based on the estimated implementation period for this remedy (~1-2 years), during which some incremental disturbance would occur (e.g., miscellaneous grading), the incremental estimated mercury vapor emissions are calculated at 7.7 pounds during remedy implementation using the 2x above baseline factor previously described (See Appendix F for calculations).
  - Construction and health and safety controls would have to be in place during implementation to limit the potential impacts to human health and environment.

- Implementability
  - Remedy implementation activities (i.e., grading, excavation, backfill, building demolition) are implementable with conventional equipment and materials.

- Cost (30 Year Net Present Worth)

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- The total estimated cost for this remedy, including 30 years of routine operation and maintenance is $24,861,000. Table 7-5 presents additional detail on the basis for this cost.

7.5.4 Site Remedy No. 4a – Full Containment and Partial Depth Selective Stabilization

Evaluation of the full containment and partial depth selective stabilization alternative against the seven criteria is summarized as follows:

- Protection of Human Health and the Environment
  - The remedy would be protective of human health and the environment through containment and through the stabilization of the upper portions of soil containing visible elemental mercury
  - The remedy would meet the RAOs as follows:
    - Direct contact exposure pathways for both COPCs related to site operations and COPCs related to anthropogenic fill would be eliminated through the implementation of a soil cap, barrier wall, treatment of the upper six-feet of soil containing visible elemental mercury, shallow groundwater collection system, and removal and on-site placement of contaminated sediments.
    - Overburden groundwater would be extracted and treated so that migration would be controlled. The barrier wall also provides a physical barrier to lateral migration. It is unlikely that applicable groundwater standards would be achieved before the overburden groundwater table has fully dissipated as a result of cutting off infiltration, as the groundwater is contained within the anthropogenic fill. However, in accordance with USEPA *Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites*, because "waste" material would remain in place, the area of attainment of cleanup levels is outside the boundary of remaining waste or in this case would be outside the boundary of the barrier wall and cap. For the purpose of this FS, the decline of the overburden groundwater is assumed to occur over a period of approximately 10 years.
    - The buildings would be demolished and the debris properly managed on Site thereby minimizing the potential for exposure to debris containing mercury and eliminating safety hazards.

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<#>Direct contact exposure pathways would be eliminated through the implementation of a soil cap, barrier wall, shallow groundwater collection system and removal and on-site placement of contaminated sediments.¶
<#>Overburden groundwater would be extracted and treated so that migration would be controlled. The barrier wall also provides a physical barrier to lateral migration. It is unlikely that applicable groundwater standards would be achieved before the overburden groundwater table has fully dissipated as a result of cutting off infiltration, as the groundwater is contained within the anthropogenic fill. For the purpose of this FS, the decline of the overburden groundwater is assumed to occur over a period of approximately 10 years.¶
<#>The buildings would be demolished and the debris properly managed on Site thereby minimizing the potential for exposure and eliminating safety hazards.¶
In addition to the above, the mercury inhalation exposure pathway would be eliminated though the implementation of a soil cap, and to the extent that mercury vapor has the potential to move laterally, it would be impeded by the barrier wall. Also, the treatment component of the soil cap would further limit the potential for exposure to mercury vapor by reducing the potential for the accumulation of mercury vapor below the cap. ¶
The site remedy would comply with ARARs to the extent practicable, as follows:¶
<#>To implement the remedy would likely require regulatory approvals (e.g., permit equivalents) for NJPDES, waterfront development, work in wetlands, fill in a floodplain, groundwater and soil remediation (new NJ SRRA requirements), a CAMU for long-term storage of contaminated media below the soil cap, work in a regulated waterway, and stormwater pollution prevention. None of these approvals would be out of the ordinary for the remedy implementation components, and should be acquired.¶
<#>Soils above relevant cleanup criteria (i.e., the NJ soil remediation standards) would be addressed.¶
<#>Overburden groundwater with concentrations of contaminants above relevant criteria (i.e., NJ groundwater quality criteria or MCLs) would be contained; however, as noted above, achieving these standards would likely not occur before the overburden groundwater table has fully dissipated as a result of cutting off infiltration because the overburden groundwater is contained within the anthropogenic fill.¶
<#>The restored portion of South Branch Creek would achieve applicable guidelines for sediment quality criteria.¶
The remedy would be effective in the long term with proper maintenance of the soil cap. The soil components have an unlimited lifespan, being ...

- Innhalation exposure pathway would be eliminated though the stabilization of visible elemental mercury in surficial soils through the implementation of a soil cap
- Due to the excess of sulfur used in the soil stabilization process, the potential for accumulation of mercury vapor below the cap would be reduced

- Compliance with ARARs
  - The remedy would comply with ARARs to the extent practicable.
  - To implement the remedy would likely require regulatory approvals (e.g., permit equivalents) for NJPDES, waterfront development, work in wetlands, fill in a floodplain, groundwater and soil remediation (new NJ SRRA requirements), a CAMU or designation as a solid waste management unit for long-term storage of contaminated media below the soil cap, an underground injection control permit equivalent if treatment occurs below the water table, work in a regulated waterway, and stormwater pollution prevention. None of these approvals would be out of the ordinary for the remedy implementation components, and should be acquired.
  - Soils above relevant cleanup criteria (i.e., the NJ soil remediation standards) would be addressed.
  - Overburden groundwater with concentrations of contaminants above relevant criteria (i.e., NJ groundwater quality criteria or MCLs) would be contained; however, as noted above, achieving these standards would likely not occur before the overburden groundwater table has fully dissipated as a result of cutting off infiltration because the overburden groundwater is contained within the anthropogenic fill, and the area of attainment would not include the containment boundaries per se, which for all intents and purposes would be the overburden groundwater zone.
  - The restored portion of South Branch Creek would achieve applicable guidelines for sediment quality criteria or alternative cleanup levels consistent with “background” levels in the Arthur Kill, as described in Section 6.
- Long-Term Effectiveness
  - The remedy would be effective in the long term with proper maintenance of the soil cap.

- The soil cap components have an unlimited lifespan, being natural materials. Geosynthetic components have typical lives in the hundreds of years, well beyond the typical planning horizon for an FS under CERCLA (i.e., 30 years). The barrier wall does not require maintenance to remain effective, and would typically have a life span in the range of 100 – 200 years, again well beyond the typical planning horizon for an FS.
- The longevity of the conversion of elemental mercury to mercuric sulfide is uncertain. However, given that under current site conditions mercury is principally present as elemental and metacinnabar, there is an expectation that following treatment the mercuric sulfide should remain fairly stable. Even if some conversion to other mercury compounds were to occur, the containment portions of the remedy would remain effective.

- Reduction of Toxicity, Mobility, or Volume
  - The remedy will reduce the mobility of site contamination through construction of the groundwater collection system and barrier wall.
  - Given the general absence of mercury migration in groundwater under existing conditions, it is unclear whether the conversion of elemental mercury to mercuric sulfide will have any material impact on mercury mobility other than the fact that mercuric sulfide is insoluble and elemental mercury has a finite, but low solubility.
  - The overall conversion efficiency of this remedy is estimated at approximately 58% (i.e., 77% of the mass in the upper six feet treated to a 75% conversion efficiency). This conversion efficiency is less than the 90% treatment goal previously described; however, an efficient containment system would be in place that should qualify as one of the modification factors, as described under the CAMU regulations. However, given that containment would then provide the requisite protectiveness, the value of the treatment component is questionable.
  - The total mass of mercury on the Site would remain unchanged and potential residual risks would also exceed the regulatory benchmarks, without the containment components related to both the contaminants from site operations and those present in the anthropogenic fill.
- Short-Term Effectiveness
  - Short-term construction impacts would exist including traffic and noise (albeit not out of the ordinary given the industrial character of the area),

dust, and an elevated potential for an increase in mercury vapor emissions due to construction activities.

- Based on the estimated implementation period for this remedy (~3-4 years), during which some incremental disturbance would occur (i.e., the in-situ stabilization process and grading), the incremental estimated mercury vapor emissions are calculated at only approximately 0.5 pounds during remedy implementation using the 2x above baseline factor previously described (See Appendix F for calculations). This limited incremental emissions rate is a consequence of mixing sulfur in the areas of visible elemental mercury, which would likely have an impact on potential mercury vapor transmission.
- Construction and health and safety controls would have to be in place during implementation to limit the potential impacts to human health and environment

- Implementability
  - Remedy implementation activities (i.e., grading, excavation, backfill, building demolition) are generally implementable with conventional equipment and materials.
  - Specialized soil mixing equipment would be used for the in-situ stabilization process, typically large or gang augers, which are available from specialized remediation contractors. However, because this remedy will involve removal of building slabs that are supported by pile caps and piles, implementability is likely to be complicated by subsurface obstructions. Because of the relatively shallow depth of the work, it may be possible to overcome these implementation problems by working around the obstructions or cutting them off below grade. Subsurface obstructions would have to be further evaluated as a part of pre-design and design work for this remedy.
  - Treatability and pilot studies would be required before implementation of the stabilization remedy to determine operating parameters and collect data on actual treatment effectiveness.
- Cost (30 Year Net Present Worth)
  - The total estimated cost for this remedy, including 30 years of routine operation and maintenance is $29,585,000 to $38,594,000 (dependent on sulfur loading for soil stabilization process). Table 7-6 presents additional detail on the basis for this cost.

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7.5.5 Site Remedy No. 4b – Full Containment and Full Depth Selective Stabilization

This site remedy is for the most part the same as combined site remedy No. 4a with the following differences:

- Reduction of Toxicity, Mobility, or Volume
  - The overall efficiency for converting elemental mercury present in soils to mercuric sulfide is estimated at 75%, assuming all of the visible elemental mercury is subjected to treatment and the conversion efficiency is 75% as previously described.
- Short-Term Effectiveness
  - Assuming that significant excavation is not required to implement the greater depth of treatment, then increased mercury emissions is likely to be similar to combined site remedy No. 4a (0.1 pounds during remedy implementation). If significant excavation is necessary, then this value could correspond to the 5x factor times baseline, as previously described, or similar to Site Remedy No. 5a, discussed subsequently (approximately 101 pounds; see Appendix F for calculations).
- Implementability
  - Because the depth of soil treatment would extend to approximately 17 feet in the area of the mercury cell buildings, implementation of this remedy would be further complicated by the presence of subsurface obstructions such as pile caps and piles. At a depth of 17 feet, working around such obstructions will be more difficult, as will cutting them off below grade. As a result, this alternative could result in the need for excavation of soils to work around obstructions, thereby increasing the potential for greater short-term mercury vapor emissions.
- Cost (30 Year Net Present Worth)
  - The total estimated cost for this remedy, including 30 years of routine operation and maintenance is $30,501,000 to $42,084,000 (dependent on sulfur loading for soil stabilization process). Table 7-7 presents additional detail on the basis for this cost.

7.5.6 Site Remedy No. 5a – Full Containment and Partial Depth Selective Excavation and Off-Site Disposal

Evaluation of the full containment and partial depth selective excavation alternative against the seven criteria is summarized as follows:

Deleted: This site remedy would be protective of human health and the environment through containment and through the stabilization of the upper portions of soil containing visible elemental mercury. This remedy would meet the RAOs as follows:¶
<#>Direct contact exposure pathways would be eliminated through the implementation of a soil cap, barrier wall, treatment of the upper six-feet of soil containing visible elemental mercury, shallow groundwater collection system, and removal and on-site placement of contaminated sediments.¶
<#>Overburden groundwater would be extracted and treated so that migration would be controlled. The barrier wall also provides a physical barrier to lateral migration. It is unlikely that applicable groundwater standards would be achieved before the overburden groundwater table has fully dissipated as a result of cutting off infiltration, as the groundwater is contained within the anthropogenic fill.¶
<#>The buildings would be demolished and the debris properly managed on Site thereby minimizing the potential for exposure to debris containing mercury and eliminating safety hazards.¶
In addition, the inhalation exposure pathway would be eliminated though the stabilization of visible elemental mercury in surficial soils through the implementation of a soil cap. Also, due to the excess of sulfur used in the soil stabilization process, the potential for accumulation of mercury vapor below the cap would be reduced. ¶
The site remedy would comply with ARARs to the extent practicable, as follows:¶
<#>To implement the remedy would likely require regulatory approvals (e.g., permit equivalents) for NJPDES, waterfront development, work in wetlands, fill in a floodplain, groundwater and soil remediation (new NJ SRRA requirements), a CAMU for long-term storage of contaminated media below the soil cap, an underground injection control permit equivalent if treatment occurs below the water table, work in a regulated waterway, and stormwater pollution prevention. None of these approvals would be out of the ordinary for the remedy implementation components, and should be acquired.¶ ...

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Deleted: <#>Because the depth of soil treatment would extend to approximately 17 feet in the area of the mercury cell buildings, implementation of this remedy would be further complicated by the presence of subsurface obstructions such as pile caps and piles. At a depth of 17 feet, working around such obstructions will be more difficult, as will cutting them off below grade. As a result, this alternative could result in the need for ...

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- Protection of Human Health and the Environment
    - The remedy would be protective of human health and the environment through containment and through the excavation and off-Site disposal of a portion of soils that contain visible elemental mercury.
    - The remedy would meet the RAOs as follows:
        - Direct contact exposure pathways for both COPCs related to site operations and COPCs related to anthropogenic fill would be eliminated through the implementation of a soil cap, barrier wall, excavation and off-site disposal of the upper six-feet of soil containing visible elemental mercury, shallow groundwater collection system, and removal and on-site placement of contaminated sediments.
        - Overburden groundwater would be extracted and treated so that migration would be controlled. The barrier wall also provides a physical barrier to lateral migration. It is unlikely that applicable groundwater standards would be achieved in the short term, as the groundwater is contained within the anthropogenic fill. However, in accordance with USEPA *Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites*, because "waste" material would remain in place, the area of attainment of cleanup levels is outside the boundary of remaining waste or in this case would be outside the boundary of the barrier wall and cap. For the purpose of this FS, the decline of the overburden groundwater is assumed to occur over a period of approximately 10 years
        - The buildings would be demolished and the debris properly managed on Site and a portion (i.e., that containing visible elemental mercury) managed through off-Site disposal. Demolition and proper debris management would minimize the potential for exposure and eliminate safety hazards.
        - The inhalation exposure pathway would be eliminated though the removal of visible elemental mercury in surficial soils and the implementation of a soil cap.
        - Due to the use of the treatment layer in the cap for this remedy, the potential for accumulation of mercury vapor below the cap would be reduced.

- Compliance with ARARs
  - The remedy would comply with ARARs to the extent practicable.
  - To implement the remedy would likely require regulatory approvals (e.g., permit equivalents) for NJPDES, waterfront development, work in wetlands, fill in a floodplain, groundwater and soil remediation (new NJ SRRA requirements), a CAMU or designation as a solid waste management unit for long-term storage of contaminated media below the soil cap, work in a regulated waterway, possibly air emissions (during excavation), and stormwater pollution prevention. None of these approvals would be out of the ordinary for the remedy implementation components, and should be able to be obtained, however, based on stringent air pollution regulations, meeting air emissions requirements for an excavation alternative may prove difficult.
  - Soils above relevant cleanup criteria (i.e., the NJ soil remediation standards) would be addressed.
  - Overburden groundwater with concentrations of contaminants above relevant criteria (i.e., NJ groundwater quality criteria or MCLs) would be contained; however, as noted above, achieving these standards would likely not occur before the overburden groundwater table has fully dissipated as a result of cutting off infiltration because the overburden groundwater is contained within the anthropogenic fill, and the area of attainment would not include the containment boundaries per se, which for all intents and purposes would be the overburden groundwater zone.
  - The restored portion of South Branch Creek would achieve applicable guidelines for sediment quality criteria or alternative cleanup levels consistent with "background" levels in the Arthur Kill, as described in Section 6.
  - Off-Site disposal of the soils containing visible elemental mercury would technically not meet the RCRA ARARs (land disposal restrictions, treatment requirements), although because disposal would be outside of the US, it would comply with relevant Canadian regulations (albeit less stringent), and provided any mercury subject to retorting is returned to the US, it would comply with the Mercury Export Ban Act.

The last item in the above ARARs discussion warrants clarification. The management of generated mercury-impacted waste is governed by the RCRA regulations. A generated waste would include any soil which has been handled

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ex-situ, including those which are treated ex-situ and placed into the same area from which they were removed. These generated wastes would be subject to RCRA land disposal restrictions (LDRs). LDRs prohibit land disposal of hazardous wastes and contaminated soils/media that contain mercury, as well as other compounds, unless the media is treated to meet specific standards (i.e., Universal Treatment Standards (UTS) found at 40 CFR 268.48) or criteria associated with the regulatory variances associated with the LDR standards. The EPA has established different sets of LDR standards for mercury containing hazardous media, each requiring a specific treatment standard. The LDRs categorize mercury containing wastes into low mercury wastes, high mercury wastes, or elemental mercury waste. These mercury waste types, along with their associated land disposal restrictions, are as follows:

Type of Waste	**Land Disposal Restrictions (Mercury UTS)**
Low Mercury Waste (< 260 mg/kg total Hg)	If Retorted, must meet 0.2 mg/L TCLP Other treatment technology, must meet 0.025 mg/L TCLP
High Mercury Waste (> 260 mg/kg total Hg)	Cannot be disposed at landfill in US, unless LDR exemption or variance is obtained. Required to be roasted or retorted. Residuals must meet 0.2 mg/L TCLP
Elemental Mercury Waste (w/ radioactive contamination)	Required to be treated by amalgamation

Contaminated soil, as stated under 40 CFR 268.49, must be treated according to either an applicable UTS, as described above, or treated in some manner to achieve the following alternative contaminated soil treatment standard (AST) prior to land disposal:

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Contaminant Type	**Alternative Contaminated Soil Treatment Standard**
Non-Metals	Treatment must achieve 90 percent reduction in total constituent concentration, except as noted below.
Metals	Treatment must achieve 90 percent reduction in constituent concentration measured in leachate from the treated media, except as noted below. -or- Treatment must achieve 90 percent reduction in total constituent concentration (for metal removal technologies), except as noted below.
Non-Metals and Metals	When treatment to 90 percent reduction standard would result in a concentration below 10 times the UTS (i.e., 0.25 mg/L TCLP for non-retorted waste), further treatment for reduction in concentration is not required.

Regulations found in 40 CFR 268.44 provide for a generator or treater of hazardous waste to apply for a variance from the treatment standards. This site-specific variance may be applicable if it is not physically possible to treat a waste to the level specified in the treatment standard, or by the method specified as the treatment standard for the particular hazardous waste. To apply for a variance from the LDR treatment standards, the petitioner must demonstrate that because the physical or chemical properties of the waste differ significantly from waste analyzed in developing the treatment standard, the waste cannot be treated to the specified levels or by the specified methods.

As previously described in Section 2, some portion of the soils containing visible elemental mercury, potentially 50% or more, could be classified as hazardous based on characteristic because of mercury concentrations in the TCLP extract (two out of four samples tested per the TCLP method failed for mercury). As such, some waste soil would have to be managed in compliance with the above regulations. This remedy could potentially involve 9,000 cubic yards or more of hazardous waste which would have to be retorted to comply with the LDRs. As of the preparation of this FS, such retort capacity does not exist in the US or elsewhere outside of the US. Typical retort capacity in the US is limited to drum or small truckload quantities. This would mean that to manage the material in the US would require a variance from the treatment standards. However, the rationale for the variance would be treatment capacity not the nature of the waste or treatment process. And, in any event, if a variance were pursued, the alternative treatment technique would be stabilization (or S/S but as previously described there are issues with this technology applied to mercury which indicated it should not be considered further). Stabilization is considered in this FS as an alternative so that such an approach would effectively eliminate the excavation and off-Site disposal alternative.

Alternatively, some other disposal facility could be identified that would not be subject to the relevant RCRA regulations, or in particular the LDRs. As of the preparation of this FS, a survey of potentially applicable disposal facilities which could accept soil containing visible elemental mercury indicated that only two disposal providers were a possibility (Emelle and USEcology/Stablex; see further discussion below) and of these, only one was identified that is known to be able to accept waste of this type. Most disposal facilities would not be able to accept soils in which visible elemental mercury was present. The facilities which could potentially accept visible elemental mercury include the Chemical Waste Management, Inc. landfill in Emelle, Alabama, and the USEcology facilities in Nevada and Utah. Both have indicated the waste could potentially be accepted

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under the alternative treatment standards (40CFR268.49). Because this alternative standard requires a treatment efficiency of 90% or to 10 times the UTS, whichever is less stringent, visible elemental mercury would not be precluded from acceptance, nor would there be an exclusion based on concentration other than the treatment requirement. However, the 90% or 10xUTS has to be demonstrated. The process used to meet these criteria is solidification/stabilization. As stated above in Section 6, solidification/stabilization has not been demonstrated on visible elemental mercury, and depending on the mix design, could increase mobility (e.g., pH dependence). Under such circumstances, visible elemental mercury impacted soils would not be accepted for disposal. Therefore, the ability for these facilities to accept the soil containing visible elemental mercury is uncertain.

This would leave only one other identified disposal facility, the USEcology/Stablex facility located in Quebec, Canada. This facility has been used for disposal of mercury contaminated soils, including, recently, soils containing concentrations in a similar range to the LCP Site and visible elemental mercury from the Ventron/Velsicol Superfund Site. The process used at the USEcology/Stablex facility for the treatment of visible elemental mercury contaminated media involves the use of a proprietary S/S technology, which is conducted as a batch method in a “mixing basin”. The S/S process, as well as media transfer operations which take place prior to S/S (i.e., railcar unloading, transferring to S/S “mixing basins”), are conducted under negative pressure. Air collected from these operations areas is treated to remove mercury vapors prior to exhausting to the atmosphere. Following the completion of the S/S process, if residual visible elemental mercury not bound within the solidified treated waste matrix remains in the “mixing basin” following the removal of the solidified treated waste, it is collected and retorted. The solidified treated waste is then disposed of at the on-site landfill.

While the USEcology/Stablex facility has been used for disposal of mercury contaminated soils similar to those found at the LCP Site, the facility has never accepted materials at the scale and with the potential quantities of mercury that would be involved at the LCP Site. USEcology/Stablex has indicated that health and safety, production capacity, pre-processing, and screening to a maximum particle size of one to two inches are issues that would need to be addressed prior to confirming acceptance.

Utilization of the USEcology/Stablex facility would require that media contaminated with visible elemental mercury be shipped outside of the United States. Shipment of these soils outside the US has potential implications with respect to the Mercury Export Ban Act, which went into effect January 1, 2013. The intent of the mercury export ban is to reduce the availability of elemental mercury in domestic and international markets. Under this Act, the export of media and debris being managed as part of a site remediation are exempt. However, if visible elemental mercury were recovered during processing of the soils and building debris, reuse or resale of that mercury would be subject to the export ban. As described above, the treatment process at the USEcology/Stablex facility may result in the recovery of visible elemental mercury. If visible elemental mercury were recovered during the treatment process, steps would have to be taken to ensure this mercury is returned to the LCP Site and that it is not reused or resold by USEcology/Stablex in violation of the export ban.

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- Long-Term Effectiveness
  - The remedy would be effective in the long term.
  - Excavation of a portion of the soils containing visible elemental mercury would permanently remove this material from the Site.
  - Proper maintenance of the soil cap would result in long-term effectiveness of this component as well. The soil components have an unlimited lifespan, being natural materials. Geosynthetic components have typical lives in the hundreds of years, well beyond the typical planning horizon for an FS under CERCLA (i.e., 30 years). The barrier wall does not require maintenance to remain effective, and would typically have a life span in the range of 100 – 200 years, again well beyond the typical planning horizon for an FS.
- Reduction of Toxicity, Mobility, or Volume
  - A reduction in contaminant volume would be achieved at the Site in the removal and off-site disposal of visible elemental mercury (approximately 77% of the visible elemental mercury impacted soil would be removed). This removal percentage estimate is less than the 90% target efficiency. However, as for other alternatives that provide a treatment component an efficient containment system would be in place that should qualify as one of the modification factors, as described under the CAMU regulations.

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- Short-Term Effectiveness
  - Short term construction impacts would exist including traffic and noise (albeit to a lesser extent given the industrial character of the area), dust, and an elevated potential for an increase in mercury vapor emissions due to construction activities.

- The excavated soils would be transported off-site, therefore, other potential short-term impacts include off-Site traffic, the potential for releases in transit, and increased greenhouse gas emissions from transportation to Canada.
- Based on the estimated remedy implementation period (~1-2 years) during which soils handling would occur, the estimated incremental mercury vapor emissions are calculated at approximately 101 pounds during remedy implementation using the 5x above baseline factor previously described (See Appendix F for calculations).
- Construction and health and safety controls would have to be in place during implementation to limit the potential impacts to human health and environment.

- Implementability
  - Remedy implementation activities (i.e., grading, excavation, backfill, building demolition) are generally implementable with conventional equipment and materials.
- Cost (30 Year Net Present Worth)
  - The total estimated cost for this remedy, including 30 years of routine operation and maintenance is 74,760,000 to $95,982,000 (dependent on potential for retorting soil following the Stablex process). Table 7-8 presents additional detail on the basis for this cost.

7.5.7 Site Remedy No. 5b – Full Containment and Full Depth Selective Excavation and Off-Site Disposal

This site remedy is for the most part the same as combined site remedy No. 5a with the following differences:

- Reduction of Toxicity, Mobility, or Volume
  - The remedy includes excavation and off-Site disposal of all the soils that have been identified as containing visible, elemental mercury.
- Short-Term Effectiveness
  - Based on the remedy duration and increased volume of material to be handled for off-Site disposal, increased mercury emissions during remedy implementation are estimated at approximately 197 pounds.

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Moved up [5]: The last item in the above ARARs warrants clarification. The management of generated mercury-impacted waste is governed by the RCRA regulations. A generated waste would include any soil which has been handled ex-situ, including those which are treated ex-situ and placed into the same area from which they were removed. These generated wastes would be subject to RCRA land disposal restrictions (LDRs). LDRs prohibit land disposal of hazardous wastes and contaminated soils/media that contain mercury, as well as other compounds, unless the media is treated to meet specific standards (i.e., Universal Treatment Standards (UTS) found at 40 CFR 268.48) or criteria associated with the regulatory variances associated with the LDR standards. The EPA has established different sets of LDR standards for mercury containing hazardous media, each requiring a specific treatment standard. The LDRs categorize mercury containing wastes into low mercury wastes, high mercury wastes, or elemental mercury waste. These mercury waste types, along with their associated land disposal restrictions, are as follows:¶
¶
Type of Waste

Deleted: This site remedy would be protective of human health and the environment through containment and through the excavation and off-Site disposal of a portion of soils that contain visible elemental mercury. ¶
This remedy would meet the RAOs as follows:¶
<#>Direct contact exposure pathways would be eliminated through the implementation of a soil cap, barrier wall, excavation and off-site disposal of the upper six-feet of soil containing visible elemental mercury, shallow groundwater collection system, and removal and on-site placement of contaminated sediments.¶
<#>Overburden groundwater would be extracted and treated so that migration would be controlled. The barrier wall also provides a physical barrier to lateral migration. It is unlikely that applicable groundwater standards would be achieved in the short term, as the groundwater is contained within the anthropogenic fill.¶
<#>The buildings would be demolished and the debris properly managed on Site and a portion (i.e., that containing visible elemental mercury) managed through off-Site disposal. Demolition and proper debris management would minimize the potential for exposure and eliminate safety hazards.¶
In addition, the inhalation exposure pathway would be eliminated though the removal of visible elemental mercury in surficial soils and the implementation of a soil cap. Also, due to the use of the treatment layer in the cap for this remedy, the potential for accumulation of mercury vapor below the cap would be reduced. ¶
The site remedy would comply with ARARs to the extent practicable, as follows:¶
<#>To implement the remedy would likely require regulatory approvals (e.g., permit equivalents) for NJPDES, waterfront ...

- Implementability
  - o Because the depth of excavation would extend to approximately 17 feet in the area of the mercury cell buildings, implementation of this remedy would be further complicated by the presence of subsurface obstructions such as pile caps and piles. At a depth of 17 feet, working around such obstructions would be more difficult, as will cutting them off below grade. As a result, this alternative could result in the need for greater time for excavation of soils to work around obstructions, thereby increasing the potential for greater mercury vapor emissions.
- Cost (30 Year Net Present Worth)
  - o The total estimated cost for this remedy, including 30 years of routine operation and maintenance is $84,332,000 to $109,658, (dependent on potential for retorting soil following Stablex process). Table 7-9 presents additional detail on the basis for this cost.

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Moved up [6]: Because the depth of excavation would extend to approximately 17 feet in the area of the mercury cell buildings, implementation of this remedy would be further complicated by the presence of subsurface obstructions such as pile caps and piles. At a depth of 17 feet, working around such obstructions would be more difficult, as will cutting them off below grade. As a result, this alternative could result in the need for greater time for excavation of soils to work around obstructions, thereby increasing the potential for greater mercury vapor emissions. ¶

Deleted: This site remedy is for the most part the same as combined site remedy No. 5a with the following differences:¶
The remedy includes excavation and off-Site disposal of all the soils that have been identified as containing visible, elemental mercury. ¶

Deleted: <#>Based on the remedy duration and increased volume of material to be handled for off-Site disposal, increased mercury emissions during remedy implementation are estimated at approximately 197 pounds. ¶

7.6 Comparative Analysis of Site Remedies

A comparative analysis was performed of the site remedies presented above to identify the relative advantages and disadvantages of each and to facilitate the selection of a remedial action for the Site. This comparative analysis is presented in Table 7-3 using the seven evaluation criteria described in Section 7.3. A review of Table 7-3 indicates the following when comparing the site remedies using the evaluation criteria:

- Protection of Human Health and the Environment
  - o As expected, because Site Remedy No. 1 – No Action was retained as a baseline for comparison with other site remedies, it does not satisfy the evaluation criteria (e.g., not protective of human health and the environment).
  - o Each of the remaining alternatives (Site Remedy Nos. 2, 3, 4a, 4b, 5a, and 5b) would meet the remedial action objectives and would generally be equally protective of human health and the environment through the elimination of the direct contact pathways (i.e., soil, groundwater, sediments) and through elimination of the inhalation pathway (i.e., mercury soil vapor).
  - o Site Remedy No. 2 – Partial Containment (Treatment Cap) may be considered marginally less protective of human health and the

environment than the other alternatives because it does not include a barrier wall, as the other combined site remedies do, which would further limit the potential for lateral migration of contamination within the site soils (e.g., vapor) and groundwater.

- o Even though Site Remedy Nos. 5a and 5b are considered protective with respect to the Site remediation, the off-Site disposal of soil containing visible elemental mercury outside of the United States raises questions about the larger scale protectiveness of these two alternatives. These Site Remedies represent the potential displacement and not necessarily the proper treatment and disposal of soils containing visible elemental mercury. The USEcology/Stablex facility uses S/S technology which as discussed in Section 6, is not a proven technology for the treatment of visible elemental mercury. In effect, it is possible, that if the S/S process (which is proprietary and therefore limited information is available) were to potentially increase mercury mobility, the protectiveness of off-Site disposal would not be improved by comparison to the soils remaining on Site (i.e., containment would provide the control in both cases).

- Compliance with ARARs:
  - o In general, with the exception of Site Remedy No. 1, the Site Remedies comply with ARARs.
  - o Site Remedy Nos. 5a and 5b, assume waste will be shipped to the USEcology/Stablex facility in Canada, therefore the disposal of waste would not violate USEPA Land Disposal Restrictions (LDRs) for mercury, as these regulations only apply within the United States. The Stablex process of S/S treatment for high subcategory mercury waste (i.e., >260 mg/kg) and elemental mercury wastes would not be permissible at a facility in the United States without a variance to LDR requirements. These alternatives also bring with them an uncertainty regarding future liability for disposal outside of the US without any meaningful added protection of human health and the environment, and without diminishing existing liability at the LCP Site.

- Long-Term Effectiveness:
  - o In general, with the exception of Site Remedy No. 1, the Site Remedies are effective in the long-term given proper maintenance of the soil cap and shallow groundwater collection systems. There is little difference between the various Site Remedies in terms of long-term effectiveness as they are all suitable to achieve the RAOs over the long term.

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- Site Remedy Nos. 4a and 4b provide an additional component to eliminate the mercury vapor pathway through conversion of visible elemental mercury to mercuric sulfide, which is a potentially permanent conversion. Treatability studies would be required prior to remedy implementation to confirm applicability of stabilization to the site soils, to define operational parameters for the in-situ stabilization process, and to determine treatment efficiencies. Such treatability testing may also shed light on the long-term stability of the conversion.
- Site Remedy Nos. 2 and 3 also provide for an additional component to eliminate the mercury vapor pathway through the implementation of a treatment cap over the area of observed visible elemental mercury. In terms of effectiveness, there is no discernible difference between Site Remedy Nos. 2, 3, 4a, and 4b in terms of eliminating the inhalation exposure pathway and limiting the potential accumulation of mercury vapor below the cap.
- Site Remedy Nos. 5a and 5b provide for the permanent transfer of a portion of the contaminated soil to an off-site disposal facility, and as such the result of this work is effective in the long-term for the site. Barring additional information to the contrary on the Stablex process and disposal facility operation, one can presume that the controls in place at that facility should be effective in the long term. In addition, while these alternatives address the preference for treatment expressed under SARA, they do so at substantially greater cost and without any real measureable benefits in protectiveness compared to the other alternatives.

- Reduction of Toxicity, Mobility, or Volume:
  - In general, with the exception of Site Remedy No. 1, the Site Remedies reduce the mobility of contaminants at the LCP site. Site Remedy Nos. 2 and 3 reduce mobility through containment, not through treatment which is the focus of this evaluation criterion. Site Remedy No. 2 potentially reduces mobility marginally less than Site Remedy No. 3 because it does not include a barrier wall component, which further limits the potential for lateral migration of contaminants. However, this difference is not substantial. Site Remedy No. 4 reduces mobility through treatment as discussed further below. Site Remedy No. 5 reduces the volume of material on Site through removal and subsequent treatment at an off-site facility, as also discussed further below.

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- Site Remedy Nos. 2 and 3 provide for the treatment of mercury vapors below the cap through the implementation of a treatment cap over the area of identified visible elemental mercury; which results in a decrease in both mobility and volume of elemental mercury. However, the total mass of mercury present on the Site remains unchanged, only its form is altered.
- Site Remedy Nos. 4a and 4b provide for conversion of visible elemental mercury to mercuric sulfide through in-situ stabilization, resulting in a potential decrease in mobility (mercuric sulfide is for all intents and purposes insoluble, whereas elemental mercury is of finite but very low solubility), and a decrease in the volume of elemental mercury. However, after stabilization the same overall mass of mercury remains in the Site soils. The only difference is additional control of the vapor pathway. Without the containment component of these remedies both would continue to exhibit unacceptable, potential excess risk from contaminants associated with the site operations as well as those present as a result of the placement of anthropogenic fill.
- Site Remedy Nos. 5a and 5b provide for the removal of visible elemental mercury, resulting in a decrease in volume, mobility and toxicity of mercury in the Site soils. As previously noted, however, the disposal options for this visible elemental mercury are limited and the only facility identified to date is outside of the United States. Also, even after removal of the portion of the contamination addressed by these alternatives, without the containment components of these remedies, the RAOs would not be met, ARARs would not be met, and potential incremental risks would remain above acceptable regulatory thresholds. As such, the value of the removal of a portion of the wastes is questionable.

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- Short-Term Effectiveness:
  - In general, Site Remedy Nos. 2 and 3 will be the quickest to implement, whereas Site Remedy Nos. 4a and 4b will require the longest implementation time period, due primarily to the time required to mix the soils during the in-situ stabilization process to achieve adequate contact between the sulfur and visible elemental mercury. In addition, Site Remedy Nos. 4a and 4b would require treatability studies, which would lengthen the remedy design process compared to the other remedies, although Site Remedy Nos. 5a and 5b may also require some pre-acceptance treatability testing as well.

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- In general, all Site Remedies will result in an increase in mercury vapor emissions over baseline conditions. Site Remedy Nos. 5a and 5b represent the largest increase in mercury vapor emissions during remedy implementation (101 to 197 pounds), and have the greatest potential for air emissions issues (permitting and/or actual performance). Site Remedy Nos. 4a and 4b represent the smallest increase in mercury vapor emissions during remedy implementation (approximately 0.5 to 0.8 pounds) because of the more widespread use of a sulfur compound. Site Remedy Nos. 2 and 3 have mercury vapor emissions in the range of 7.7 pounds. While these mass emissions estimates are small by comparison to mercury emissions from say manufacturing, the differences among the remedies are substantial when one considers that the effectiveness and protectiveness of the remedies are nearly identical.

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- Implementability:
  - In general, all Site Remedies are implementable with conventional materials and equipment.
  - Site Remedy Nos. 4a and 4b would require specialized equipment for soil mixing.
  - Site Remedy Nos. 4b and 5b are inherently more difficult to implement than Site Remedy Nos. 4a and 5a due to greater depth of remedy implementation and the associated subsurface obstructions, as previously discussed.
  - Site Remedy Nos. 5a and 5b, as previously discussed, require transport and disposal of visible elemental mercury wastes outside the United States. These alternatives are limited to a sole source, and this source (USEcology/Stablex) has indicated uncertainty regarding the ability to provide the requisite disposal capacity. In addition, uncertainty exists in the actual treatment process employed by Stablex (proprietary and therefore information is limited) and the potential for a significant amount of non-stabilized visible elemental mercury wastes to require retorting following the application of the Stablex process.
- Cost:
  - Site Remedy No. 2 is the least expensive remedy whereas Site Remedy No. 5b is the most expensive. As demonstrated in the comparisons above, Site Remedy No. 3 provides a level of protectiveness equal to the other alternatives and slightly better than alternative No. 2, but at a cost roughly

20-70% less than Site Remedy Nos. 4a and 4b, and roughly 350-450% less than Site Remedy Nos. 5a and 5b.

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SITE REMEDY MERCURY EMISSION CALCULATIONS

Table 4-1
Site-Specific ARARs
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Standard, Requirement, or Criterion	Citation or Reference	Type	Description	Status	Comments
FEDERAL					
Air: Clean Air Act	42 USC 7401, Section 112	Action specific	Establishes limits on emissions to atmosphere from industrial and commercial activities.	Applicable	Applicable to alternatives that may emit pollutants to the air.
National Ambient Air Quality Standards (NAAQS)	40 CFR Part 50	Action specific	Establishes emissions limits for primary and secondary NAAQS	Applicable	Applicable to alternatives that may emit pollutants to the air
Standards of Performance for New Stationary Sources	40 CFR Part 60	Action specific	Establishes emissions requirements for new stationary sources	Applicable	Applicable to alternatives that may emit pollutants to the air
National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR Part 61	Action specific	Establishes limits on hazardous emissions to the atmosphere	Applicable	Applicable to alternative that may emit pollutants to the air. Sets requirements for public exposure to hazardous airborne emissions.
OSHA Permissible Exposure Limits	29 CFR 1910.1000	Chemical specific	Provides time weighted average exposure concentrations for workers for air pollutants	Applicable	Applicable to alternatives where workers are exposed to air pollutants.
Vapor Intrusion Guidance	OSWER Draft Guidance Document	Chemical specific	Provides soil vapor, indoor air screening levels	TBC	Potentially applicable depending on ultimate redevelopment of the site (i.e., redeveloped with buildings)
Fish and Wildlife: Fish and Wildlife Coordination Act	16 USC 661, 40 CFR 6.302(g)	Location specific	Provides protection of fish and wildlife from actions resulting in the control or structural modification of natural streams and water bodies.	Relevant and Appropriate	Potentially applicable to alternatives involving placement of fill in South Branch Creek.
Endangered Species Act	16 USC 1531(h) through 1543, 50 CFR 17,402, and 40 CFR 6.302(b)	Location specific	Provide protection of endangered/threatened species and against adversely modifying/destroying of critical habitats	Relevant and Appropriate	Threatened or endangered species not identified at the site; not likely applicable.
Groundwater: Maximum Contaminant Levels (MCLs)	40 CFR Part 141	Chemical specific	Maximum permissible levels of contaminants in water that is delivered to any user of a public water system.	Relevant and Appropriate	Applicable to determining whether groundwater if used from the Site for drinking would require treatment to reduce concentrations to levels below the MCLs. Groundwater at the site is not anticipated to be used.

Table 4-1
Site-Specific ARARs
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Standard, Requirement, or Criterion	Citation or Reference	Type	Description	Status	Comments
Underground Injection Control Program	40 CFR Part 146	Action specific	Establishes technical criteria and standards for underground injection wells.	Relevant and Appropriate	Potentially applicable if the remedial activities include in-situ soil treatment technologies below the groundwater table.
Hazardous Waste: General Hazardous Waste Management System Regulations	40 CFR Part 260	Action specific	Provides definitions of terms and general standards applicable to hazardous waste management system regulations.	Applicable	Applicable if remedial activities include the management of hazardous waste.
Identification and Listing of Hazardous Waste	40 CFR Part 261	Chemical specific	Defines those wastes, which are subject to regulation as hazardous wastes, and lists specific chemical and industry-source wastes.	Applicable	Applicable to determining whether wastes are hazardous, and to brine sludge in closed RCRA unit.
Generators of Hazardous Waste	40 CFR 262	Chemical specific	Establishes requirements for generators of hazardous waste (EPA ID numbers and manifests).	Applicable	Applicable to remedial activities that involve the management of a hazardous waste.
Transportation of Hazardous Wastes.	40 CFR 263 and 49 CFR 107, 171-180	Action specific	Established standards for the transportation of hazardous wastes and/or materials.	Applicable	Applicable to remedial activities that involve the off-site transportation of hazardous waste.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR 264	Action, location, and chemical specific	Establishes the minimum standards for the management of hazardous waste and includes regulations for land disposal units.	Applicable	Applicable to remedial activities that include disposal of hazardous wastes, or treatment of hazardous waste at the site.
Land Disposal Restrictions	40 CFR 268	Chemical specific	Identifies hazardous wastes which are restricted from land disposal and identifies treatment requirements prior to disposal	Applicable	Applicable to remedial activities that include disposal of hazardous wastes.
Soil: Mercury Export Ban Act	Public Law 110-414 (122 STAT. 4341 – 4348)	Action and chemical specific	Establishes export and resale ban of elemental mercury containing materials. Remediation wastes may be exported for treatment/disposal but not for sale or reuse of any recovered mercury.	Applicable	Applicable to remedial activities that include international, off-site disposal of elemental mercury.
Surface Water: Clean Water Act (CWA)	33 USC 1342	Action and chemical specific	Sets standards for the restoration and maintenance of chemical, physical and biological characteristics of surface water.	Applicable/ TBC	Applicable for selected remedial technologies (e.g., surface water discharge), and potentially assessment of South Branch Creek.
National Pollutant Discharge Elimination System	40 CFR 122	Action and chemical specific	Requires permits for the discharge of pollutants from any point source into waters of the United States	Applicable	Applicable for selected remedial technologies (e.g., surface water discharge of treated groundwater)

Table 4-1
Site-Specific ARARs
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Standard, Requirement, or Criterion	Citation or Reference	Type	Description	Status	Comments
Wetlands and Costal Zone: Executive Order No. 11990 - Protection of Wetlands	40 CFR 6.302(a) and Appendix A	Location specific	Requires Federal agencies to take action to avoid adversely impacting wetlands wherever possible and to minimize wetlands destruction.	Applicable	Applicable to remedial actions that affect wetland areas.
Executive Order No. 11988 - Floodplain Management	40 CFR 6.302(b) and Appendix A	Location specific	Requires Federal agencies to evaluate the potential effects of actions it may take in a floodplain to avoid adversely impacting floodplains wherever possible.	Applicable	Applicable to remedial actions that affect floodplains.
Section 404 CWA	33 CFR 330	Location and Action Specific	Regulates discharge of dredged or fill material into waters of the United States	Applicable	Applicable to remedial actions that may involve placement of fill in South Branch Creek.
Wetland Permits	40 CFR 230 – 233	Location specific	Provides wetland permitting requirements for actions in and around wetlands and waters of the United States	Applicable	Applicable to remedial actions that may impact wetlands and/or placement of fill in South Branch Creek.
Coastal Zone Management Act	16 USC 1451, Section 302	Location specific	Establishes state program to preserve, protect, develop, and restore or enhance resources of the Nation's coastal zone	Applicable	Applicable to remedial actions that occur within a coastal zone, however, coastal zone is not present adjacent to the site.
Other: Comprehensive Environmental Response, Compensation, and Liability Act and Superfund Amendments and Reauthorization Act	40 CFR 300, Subpart E	Action specific	Outlines procedures for remedial action planning and implementation	Applicable	Applicable to Superfund remedial actions
STATE OF NEW JERSEY					
Air: Permits and Certificates for Minor Facilities	NJAC 7:27-8	Action specific	Governs permits and certificates for facilities classified as minor air pollution sources.	Applicable	Applicable if the selected remediation system qualifies as a minor air pollution source (e.g., groundwater treatment of VOCs).
Ambient Air Quality Standards	NJAC 7:27-13	Action and chemical specific	Establishes air quality standards for the protection of public health and the preservation of ambient air quality.	Applicable	Applicable to remedial alternatives that result in air emissions (e.g., groundwater treatment of VOCs).

Table 4-1
Site-Specific ARARs
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Standard, Requirement, or Criterion	Citation or Reference	Type	Description	Status	Comments
Control and Prohibition of Air Pollution from Diesel-Powered Motor Vehicles, Gasoline-Powered Motor Vehicles, VOCs, Toxic Compounds	NJAC 7:27-14, 15, 16, 17	Action and chemical specific	Establishes allowable emissions from general industrial process source categories.	Applicable	Applicable to remedial alternatives that result in air emissions, such as VOCs.
Control and Prohibition of Air Pollution from New or Altered Sources Affecting Ambient Air Quality (Emission Offset Rules)	NJAC 7:27-18	Action and chemical specific	Establishes air quality guidelines and standards for specific sources.	Applicable	Applicable to contaminant emissions during remedial activities that may impact ambient air quality.
Operating Permits and Certificates	NJAC 7:27-22	Action specific	Describes requirements and procedures for obtaining operating permits and certificates for major air pollution sources	Applicable	Applicable to remedial alternatives that result in air emissions such as groundwater treatment for VOCs.
Vapor Intrusion Guidance	NJDEP Guidance Document, October 2005	Chemical specific	Provides soil vapor, indoor air, rapid action, and health department notification screening levels	TBC	Potentially applicable depending on ultimate redevelopment of the site.
Fish and Wildlife: Endangered and Threatened Species	NJAC 7:13-3.9	Location specific	Identifies endangered and threatened species and species of special concern.	Relevant and Appropriate	Threatened or endangered species not identified at the site; not likely applicable.
Groundwater: New Jersey Primary Drinking Water Standards	NJAC 7:10-5	Chemical specific	Maximum permissible levels of contaminants in water that are delivered to any user of a public water system.	TBC	Applicable to determining whether groundwater if used from the Site for drinking would require treatment to meet the MCLs. Groundwater at the site is not anticipated to be used.
Groundwater Quality Standards	NJAC 7:9C	Chemical specific	Lists the maximum permissible levels of contaminants in groundwater.	Applicable	Applicable to groundwater remedial alternatives.
Underground Injection Control Program	NJAC 7:14A-8	Action specific	Establishes controls for injection practices	Relevant and Appropriate	Potentially applicable if the remedial activities include in-situ treatment technologies below the groundwater table.

Table 4-1
Site-Specific ARARs
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Standard, Requirement, or Criterion	Citation or Reference	Type	Description	Status	Comments
Hazardous and Solid Waste:					
Identification and Listing of Hazardous Waste	NJAC 7:26G-5	Chemical specific	Describes methods for identifying hazardous wastes and lists known hazardous wastes.	Applicable	Applicable to determining whether wastes are hazardous.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities	NJAC 7:26G-8	Action specific	Establishes permit requirements and construction and operations standards.	Applicable	Applicable if remedial activities include the treatment, storage, and/or disposal of hazardous waste.
Land Disposal Restrictions	NJAC 7:26G-11	Action and chemical specific	Identifies hazardous wastes that are subject to land disposal restrictions	Applicable	Applicable if remedial activities include the disposal of hazardous waste
Transportation of Hazardous Materials	NJAC 16:49	Action specific	Regulates shipping/transport of hazardous materials.	Applicable	Applicable if action includes off-site transport of hazardous materials
Solid Waste Regulations	NJAC 7:26	Action specific	Regulates non-hazardous waste management.	Applicable	Applicable if action includes generation or management of solid wastes.
Sediment					
Guidance for Sediment Quality Evaluations	NJDEP Guidance Document, May 2011	Chemical specific	Establishes guidance for sediment evaluation to be used in ecological risk assessment process under Site Remediation Program	TBC	Provides basis for determining sediment cleanup criteria for remedial actions
Surface Water:					
Storm Water Management	NJAC 7:8	Action specific	Establishes requirements for managing and controlling storm water from the site.	Applicable	Applicable if conditions are altered for remedial activities.
Surface Water Standards	NJAC 7:9B	Chemical specific	Sets standards for the restoration and maintenance of chemical, physical and biological characteristics of surface water.	Applicable/ TBC	Applicable to certain remedial technologies (e.g., surface water discharge), and potentially assessment of South Branch Creek.
Flood Hazard Area Control	NJAC 7:13	Location specific	Controls and limits development in flood plains	Applicable	Applicable to remedial activities in a flood plain.
New Jersey Pollutant Discharge Elimination System Rules	NJAC 7:14A	Action and chemical specific	Establishes standards for surface water discharge for site remediation projects. Takes precedence over National Pollution Discharge Elimination System regulations (40 CFR 122 and 125)	Applicable	Potentially applicable if remedial activities include discharge to surface water.
Treatment Works Approval	NJAC 7:14A-22,23	Action and chemical specific	Regulates the construction and operation of industrial and domestic wastewater collection, conveyance, and treatment facilities.	Relevant and Appropriate	Potentially applicable if remedial activities include a treatment plant or pre-treatment plant with discharge to POTW.

Table 4-1
Site-Specific ARARs
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Standard, Requirement, or Criterion	Citation or Reference	Type	Description	Status	Comments
Soil: Soil Erosion and Sediment Control/Mitigation	NJAC 7:13-3.3, 3.4	Action specific	Requires controls for erosion and sediment transport.	Applicable	Applicable to construction activities that disturb soils.
Remediation Standards	NJAC 7:26D	Chemical specific	Soil site-specific cleanup levels. Includes guidance on development of impact to groundwater soil remediation standards. Regulations also include remediation standards for groundwater and surface water.	Applicable	Provides soil, groundwater, and surface water cleanup objectives.
Wetlands and Costal Zone: Freshwater Wetland Protection Act Rules	NJAC 7:7A	Location specific	Establishes requirements for the protection of freshwater wetlands.	Applicable	Applicable to remedial actions that affect wetland areas, such as adjacent to South Branch Creek.
Coastal Permit Program Rules	NJAC 7:7	Location specific	Establishes requirements for the protection of coastal areas.	Applicable	Applicable to remedial actions that occur within a coastal zone. Coastal zone (CAFRA) is not present adjacent to the site, however, waterfront development requirements would apply.
Other: Noise Control	NJAC 7:29	Action specific	Limits the noise generated from any industrial, commercial, public service or community service facility.	Applicable	Limits the noise that can be generated during remedial activities.
Technical Requirements for Site Remediation	NJAC 7:26E	Action specific	Specifies requirements for remedial activities within New Jersey.	Applicable	State program ~~for review of~~for implementation of remedial activities and part of Licensed Site Remediation Professional program.
Well Construction and Maintenance, Sealing of Abandoned Wells	NJAC 7:9D	Action specific	Specifies requirements for installation and abandonment of wells.	Applicable	Applicable to remedial action that involve construction or abandonment of wells.
NJDEP Site Remediation Guidance Library	NJAC 7:26C	Action and/or location specific	Provide technical guidance for various aspects of site remediation	Applicable	State program for implementation of remedial activities and part of Licensed Site Remediation Professional program.

TABLE 2-4
Chemicals of Potential Concern (COPCs)

COPC	Soil	Groundwater	Sediment	SITE(2)		Basis
				YES	NO	
Aluminum		x			x	E
Antimony	x	x			x	A,B,E
Arsenic	x	x	x		x	A,B,D,E,F
Barium	x	x	x		x	A,B,E
Beryllium	x				x	B
Cadmium	x	x	x		x	A,B,D,E,F
Chromium	x	x	x		x	B,E,F
Cobalt	x	x			x	A,B,D,E
Copper			x		x	B,F
Iron	x	x	x		x	A,C,E
Lead	x	x	x		x	B,D,E,F
Manganese		x	x		x	A,B,E
Mercury	x	x	x	x		A,B,D,E,F
Nickel		x	x		x	E,F
Selenium	x				x	B
Silver			x		x	F
Vanadium	x	x	x		x	A,B
Zinc	x		x		x	B,D,F
Acenaphthene			x		x	F
Acenaphthylene			x		x	F
alpha-chlordane	x				x	B
Aniline		x			x	E
Anthracene			x		x	F
Benz(a)anthracene	x	x	x		x	A,D,E,F
Benzo(a)pyrene TEQ	x		x		x	A,D,F
Benzo(b)fluoranthene	x				x	D
Benzo(k)fluoranthene	x				x	D
Carbazole		x			x	A
Chloroaniline, p-		x			x	A,E
Chrysene			x		x	F
Dibenz(a,h)Anthracene	x		x		x	D,F
Fluoranthene			x		x	F
Fluorene			x		x	F
Dichlorobenzene, 1,2-		x			x	A,E
Dichlorobenzene, 1,4-	x	x			x	A,D,E
Dichlorophenol, 2,4-		x			x	E
Dinitrotoluene, 2,4-	x				x	D
Dinitrotoluene, 2,6-	x				x	D
Hexachlorobenzene	x	x		x		A,B,D,E
Hexachlorobutadiene	x	x			x	D,E
Indeno(1,2,3-c,d) Pyrene	x				x	D
Naphthalene	x	x	x		x	A,D,E,F
Nitrobenzene		x			x	A,E
Methylnaphthalene, 2-		x	x		x	E,F
PCBs	x		x	x		A,B,D,F
PCDDs		x	x		x	A,B
PCDFs	x	x	x	x		A,B
Pentachlorophenol		x			x	A,E
Phenanthrene			x		x	F
Pyrene			x		x	F
Trichlorobenzene, 1,2,4-	x	x			x	A,D,E
Toulene		x			x	E
Benzene		x			x	A,D,E
Chloride		x			x	E
Chlorobenzene		x			x	A,E
Chloroform	x				x	D
Dibromoethane, 1,2-	x				x	D
DBCP	x				x	D
Ethylbenzene		x			x	A
Methylene Chloride	x	x			x	A,D,E
Tetrachloroethylene (PCE)	x	x			x	A,D,E
Trichloroethylene (TCE)	x	x			x	A,B,D,E
Vinyl Chloride		x			x	A

Notes:
1. Sodium found in overburden groundwater above NJDEP Class IIA Standards. However, due to brackish nature of the groundwater, it is not included as a COPC.

2. "Site" indicates whether a contaminant is associated with the chlor-alkali operations or is likely from another source.

Basis Key:
A - Human Health Risk
B - Ecological Risk (BERA COPC Table)
C - Also included from BERA Problem Formulation with USEPA
D - Greater than NJDEP Non-Residential Direct Contact Soil Remediation Standard
E - Greater than NJDEP Class IIA Ground Water Quality Criterion
F - Greater than NJDEP Sediment Screening Level

TABLE 4-2
Preliminary Remediation Goals (PRGs)

COPC	SOIL			GROUNDWATER (CLASS IIA)[6]				SEDIMENT		
	EPA RSL INDUSTRIAL	NJDEP NON-RESIDENTIAL REM. STD	PRG[5]	EPA RSL TAPWATER	CWA MCL	NJDEP GW STD	PRG	ER-L	ER-M	PRG[7]
Units	mg/kg	mg/kg	mg/kg	ug/L	ug/L	ug/L	ug/L	mg/kg	mg/kg	mg/kg
Aluminum				1.6E+04	-	2.0E+02	2.0E+02			
Antimony	4.1E+02	4.5E+02	450	6.0E+00	6.0E+00	6.0E+00	6			
Arsenic	1.6E+00	1.9E+01	19	4.5E-02	1.0E+01	3.0E+00	3	8.2E+00	7.0E+01	8.2
Barium	1.9E+05	5.9E+04	59,000	2.9E+03	2.0E+03	6.0E+03	6,000	-	4.8E+01	48
Beryllium	2.0E+03	1.4E+02	140							
Cadmium	8.0E+02	7.8E+01	78	6.9E+00	5.0E+00	4.0E+00	4	1.2E+00	9.6E+00	1.2
Chromium				-	1.0E+02	7.0E+01	70	8.1E+01	3.7E+02	81
Cobalt	3.0E+02	5.9E+02	590	4.7E+00	-	-	4.7			
Copper								3.4E+01	2.7E+02	34
Iron	7.2E+05	-	720,000	1.1E+04	-	3.0E+02	300	-	-	-
Lead	8.0E+02	8.0E+02	800	-	1.5E+01	5.0E+00	5	4.7E+01	2.2E+02	47
Manganese				3.2E+02	-	5.0E+01	50	-	2.6E+02	260
Mercury[1]	4.3E+01	6.5E+01	65	6.3E-01	2.0E+00	2.0E+00	2	1.5E-01	7.1E-01	0.15
Nickel				3.0E+02	-	1.0E+02	100	2.1E+01	5.2E+01	21
Selenium	5.1E+03	5.7E+03	5,700							
Silver								1.0E+00	3.7E+00	1
Vanadium	5.2E+03	1.1E+03	1,100	7.8E+01	-	6.0E+01	60	-	5.7E+01	57
Zinc	3.1E+05	1.1E+05	110,000					1.5E+02	4.1E+02	150
Acenaphthene								1.6E-02	5.0E-01	0.016
Acenaphthylene								4.4E-02	6.4E-01	0.044
alpha-chlordane[2]	6.5E+00	1.0E+00	1							
Aniline				1.2E+01	-	6.0E+00	6			
Anthracene								8.5E-02	1.1E+00	0.085
Benz(a)anthracene	2.1E+00	2.0E+00	2	2.9E-02	-	-	0.029	2.6E-01	1.6E+00	0.261
Benzo(a)pyrene TEQ	2.1E-01	2.0E-01	0.2					4.3E-01	1.6E+00	0.43
Benzo(b)fluoranthene	2.1E+00	2.0E+00	2							
Benzo(k)fluoranthene	2.1E+01	2.3E+01	23							
Carbazole				-	-	-	-			
Chloroaniline, p-				3.2E-01	-	3.0E+01	30			
Chrysene								3.8E-01	2.8E+00	0.384
Dibenz(a,h)anthracene	2.1E-01	2.0E-01	0.2					6.3E-02	2.6E-01	0.063
Fluoranthene								6.0E-01	5.1E+00	0.6
Fluorene								1.9E-02	5.4E-01	0.019
Dichlorobenzene, 1,2-				2.8E+02	6.0E+02	6.0E+02	600			
Dichlorobenzene, 1,4-	1.2E+01	1.3E+01	13	4.2E-01	7.5E+01	7.5E+01	75			
Dichlorophenol, 2,4-				3.5E+01	-	2.0E+01	20			
Dinitrotoluene, 2,4-	5.5E+00	3.0E+00	3							
Dinitrotoluene, 2,6-	6.2E+02	3.0E+00	3							
Hexachlorobenzene	1.1E+00	1.0E+00	1	4.2E-02	1.0E+00	2.0E-02	0.02			
Hexachlorobutadiene	2.2E+01	2.5E+01	25	2.6E-01	-	1.0E+00	1			
Indeno(1,2,3-c,d) Pyrene	2.1E+00	2.0E+00	2							
Naphthalene[3]	1.8E+01	1.7E+01	17	1.4E-01	-	3.0E+02	0.14	1.6E-01	2.1E+00	0.16
Nitrobenzene				1.2E-01	-	6.0E+00	6			
Methylnaphthalene, 2-				2.7E+01	-	-	27	7.0E-02	6.7E-01	0.07
PCBs[4]	7.4E-01	1.0E+00	1					5.0E-03	2.4E+01	0.005
PCDDs				5.2E-07	3.0E-05	1.0E-05	1.0E-05	-	-	-
PCDFs	1.0E+03	-	1,000	5.8E+00	-	-	5.8	-	-	-
Pentachlorophenol				3.5E-02	1.0E+00	3.0E-01	0.3			
Phenanthrene								2.4E-01	1.5E+00	0.24
Pyrene								6.7E-01	2.6E+00	0.665
Trichlorobenzene, 1,2,4-	9.9E+01	8.2E+02	820	9.9E-01	7.0E+01	9.0E+00	9			
Benzene				3.9E-01	5.0E+00	1.0E+00	1			
Chlorobenzene				7.2E+01	1.0E+02	5.0E+01	50			
Chloroform	1.5E+00	2.0E+00	2							
Dibromoethane, 1,2-	1.7E-01	4.0E-02	0.04							
DBCP	6.9E-02	2.0E-01	0.2							
Ethylbenzene				1.3E+00	7.0E+02	7.0E+02	700			
Methylene Chloride	9.6E+02	9.7E+01	97	9.9E+00	5.0E+00	3.0E+00	3			
Tetrachloroethylene (PCE)	1.1E+02	5.0E+00	5	9.7E+00	5.0E+00	1.0E+00	1			
Trichloroethylene (TCE)	6.4E+00	2.0E+01	20							
Vinyl Chloride				1.5E-02	2.0E+00	1.0E+00	1			

Notes:
1. Elemental Mercury used for PRG selection
2. Criteria for combined alpha- and gamma-chlordane
3. EPA Tapwater RSL chosen for Naphthalene due to updated toxicity information
4. Criteria based on Aroclor 1260
5. Based on non-residential regulatory standard or if no standard then industrial guidance value. IGW values provided for information only. Groundwater evaluated separately.
6. Overburden groundwater only
7. PRGs provided as a point of reference. See Section 4.2.3 for discussion of Arthur Kill "background" which may be taken into consideration in developing cleanup levels as part of remedial design.
8. "-" indicates no criteria or standard
9. Shading indicates constituent is not a COPC for given medium

Table ES-1
Combined Site Remedies
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Remedy	Combined Site Remedy Description
1	***No Action***
2	***Partial Containment (Treatment Cap)***
	Treatment Cap, Soils and Groundwater [1]
	Shallow Groundwater Collection[1]
	So. Branch Ck. Sediments Selective Excavation and On-Site Disposal, Restore Wetlands [2]
	Building Demolition, Recycle Steel, and On-Site Disposal [3]
3	***Full Containment (Treatment Cap and Barrier Wall)***
	Treatment Cap and Barrier Wall, Soils and Groundwater [1]
	Shallow Groundwater Collection[1]
	So. Branch Ck. Sediments Selective Excavation and On-Site Disposal, Restore Wetlands[2]
	Building Demolition, Recycle Steel, and On-Site Disposal [3]
4a	***Full Containment and Partial Depth Stabilization***
	Cap, Soils and Groundwater with Stabilization of Soils with Visible Mercury [1]
	Barrier Wall and Shallow Groundwater Collection [1]
	So. Branch Ck. Sediments Excavation and On-Site Disposal, Restore Wetlands[2]
	Building Demolition, Recycle Steel, and On-Site Disposal [3]
4b	***Full Containment and Full Depth Stabilization***
	Cap, Soils and Groundwater with Stabilization of Soils with Visible Mercury [1]
	Barrier Wall and Shallow Groundwater Collection [1]
	So. Branch Ck. Sediments Excavation and On-Site Disposal, Restore Wetlands[2]
	Building Demolition, Recycle Steel, and On-Site Disposal [3]
5a	***Full Containment and Partial Depth Selective Excavation and Off-Site Disposal***
	Treatment Cap, Soil and Groundwater with Excavation and Off-Site Disposal of Soils with Visible Mercury [1]
	Barrier Wall and Shallow Groundwater Collection [1]
	So. Branch Ck. Sediments Excavation and On-Site Disposal, Restore Wetlands[2]
	Building Demolition, Recycle Steel, and On-Site/Off-Site Disposal [3]
5b	***Full Containment and Full Depth Selective Excavation and Off-Site Disposal***
	Cap, Soil and Groundwater with Excavation and Off-Site Disposal of Soils with Visible Mercury [1]
	Barrier Wall and Shallow Groundwater Collection [1]
	So. Branch Ck. Sediments Excavation and On-Site Disposal, Restore Wetlands[2]
	Building Demolition, Recycle Steel, and On-Site/Off-Site Disposal [3]

[1] Area encompassed by containment and shallow groundwater collection systems estimated at 24 ± acres (includes filling of So. Branch Ck.)

[2] Includes backfilling of upstream portion of So. Branch Ck.

[3] Building remediation alternatives assume demolished building materials remain on-site except for off-site disposal options. Building materials contaminated with visible mercury to be treated by soils treatment method, if applicable, prior to on-site disposal or to be disposed of off-site

[4] Modification eliminates barrier wall component

[5] Modification adds treatment cap component

Table ES-2. Detailed Evaluation of Site Remedies, Page 1 of 4
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Evaluation Criteria	**Site Remedy No. 1** No Action	**Site Remedy No. 2** Partial Containment (Treatment Cap)	**Site Remedy No. 3** Full Containment (Treatment Cap and Barrier Wall)	**Site Remedy No. 4a** Full Containment and Partial Depth Selective Stabilization	**Site Remedy No. 4b** Full Containment and Full Depth Selective Stabilization	**Site Remedy No. 5a** Full Containment and Partial Depth Selective Excavation and Off-Site Disposal	**Site Remedy No. 5b** Full Containment and Full Depth Selective Excavation and Off-Site Disposal
Protection of Human Health and the Environment	**Not protective of human health and the environment. Does not meet RAOs.**	**Protective of human health and the environment. Meets RAOs.** Eliminates exposure pathways for: • Soils • Sediments • Groundwater • Soil vapor.	**Protective of human health and the environment. Meets RAOs.** Eliminates exposure pathways for: • Soils • Sediments • Groundwater • Soil vapor. Barrier wall provides additional level of containment	**Protective of human health and the environment. Meets RAOs.** Eliminates exposure pathways for: • Soils • Sediments • Groundwater • Soil vapor. Barrier wall provides additional level of containment	**Protective of human health and the environment. Meets RAOs.** Eliminates exposure pathways for: • Soils • Sediments • Groundwater • Soil vapor. Barrier wall provides additional level of containment	**Protective of human health and the environment. Meets RAOs.** Eliminates exposure pathways for: • Soils • Sediments • Groundwater • Soil vapor. Barrier wall provides additional level of containment	**Protective of human health and the environment. Meets RAOs.** Eliminates exposure pathways for: • Soils • Sediments • Groundwater • Soil vapor. Barrier wall provides additional level of containment
Compliance w/ ARARs	**Does not comply with ARARs** (e.g., soil remediation standards).	**Complies with ARARs.** Typical regulatory approvals required (e.g., CWA Section 404, wetlands, NJDEP remediation, CAMU, SWMU, NJPDES), as permit equivalents where appropriate. Addresses soil remediation standards, and sediment quality guidelines. Addresses groundwater quality standards over the long-term (groundwater in anthropogenic fill), or through elimination of the overburden groundwater mound.	**Complies with ARARs.** Typical regulatory approvals required (e.g., CWA Section 404, wetlands, NJDEP remediation, CAMU, SWMU, NJPDES), as permit equivalents where appropriate. Addresses soil remediation standards, and sediment quality guidelines. Addresses groundwater quality standards over the long-term (groundwater in anthropogenic fill), or through elimination of the overburden groundwater mound.	**Complies with ARARs.** Typical regulatory approvals required (e.g., CWA Section 404, wetlands, NJDEP remediation, CAMU, SWMU, NJPDES), as permit equivalents where appropriate. Potential underground injection control approval required for soils remedial action if implemented below water table. Addresses soil remediation standards, and sediment quality guidelines. Addresses groundwater quality standards over the long-term (groundwater in anthropogenic fill), or through elimination of the overburden groundwater mound.	**Complies with ARARs.** Typical regulatory approvals required (e.g., CWA Section 404, wetlands, NJDEP remediation, CAMU, SWMU, NJPDES), as permit equivalents where appropriate. Potential underground injection control approval required for soils remedial action if implemented below water table. Addresses soil remediation standards, and sediment quality guidelines. Addresses groundwater quality standards over the long-term (groundwater in anthropogenic fill), or through elimination of the overburden groundwater mound.	**Complies with ARARs.** Typical regulatory approvals required (e.g., CWA Section 404, wetlands, NJDEP remediation, CAMU, SWMU, NJPDES), as permit equivalents where appropriate. Potential air permit required for soils remedial action. LDRs would apply if material managed in the US. Mercury Export Ban Act requirements would apply if material is exported from the US. Addresses soil remediation standards, and sediment quality guidelines. Addresses groundwater quality standards over the long-term (groundwater in anthropogenic fill), or through elimination of the overburden groundwater mound.	**Complies with ARARs.** Typical regulatory approvals required (e.g., CWA Section 404, wetlands, NJDEP remediation, CAMU, SWMU, NJPDES), as permit equivalents where appropriate. Potential air permit required for soils remedial action. LDRs would apply if material managed in the US. Mercury Export Ban Act requirements would apply if material is exported from the US. Addresses soil remediation standards, and sediment quality guidelines. Addresses groundwater quality standards over the long-term (groundwater in anthropogenic fill), or through elimination of the overburden groundwater mound.

Table ES-2. Detailed Evaluation of Site Remedies, Page 2 of 4
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Evaluation Criteria	**Site Remedy No. 1** No Action	**Site Remedy No. 2** Partial Containment (Treatment Cap)	**Site Remedy No. 3** Full Containment (Treatment Cap and Barrier Wall)	**Site Remedy No. 4a** Full Containment and Partial Depth Selective Stabilization	**Site Remedy No. 4b** Full Containment and Full Depth Selective Stabilization	**Site Remedy No. 5a** Full Containment and Partial Depth Selective Excavation and Off-Site Disposal	**Site Remedy No. 5b** Full Containment and Full Depth Selective Excavation and Off-Site Disposal
Long-Term Effectiveness	**No action, therefore, no long-term effectiveness.**	**Effective in the long-term with proper maintenance of containment components.** Containment components provide long-term performance.	**Effective in the long-term with proper maintenance of containment components.** Containment components provide long-term performance. Barrier wall does not require routine maintenance.	**Effective in the long-term with proper maintenance of containment components.** Containment components provide long-term performance. Barrier wall does not require routine maintenance. **Treatment long-term effectiveness uncertain.** Longevity of conversion of visible elemental mercury to mercuric sulfide is uncertain, but mercuric sulfide expected to predominate over the long-term. If mercury species change with time, containment components remain effective **Potential site risks remain without containment components.**	**Effective in the long-term with proper maintenance of containment components.** Containment components provide long-term performance. Barrier wall does not require routine maintenance. **Treatment long-term effectiveness uncertain.** Longevity of conversion of visible elemental mercury to mercuric sulfide is uncertain, but mercuric sulfide expected to predominate over the long-term. If mercury species change with time, containment components remain effective **Potential site risks remain without containment components.**	**Effective in the long-term with proper maintenance of containment components.** Containment components provide long-term performance. Barrier wall does not require routine maintenance. **Potential site risks remain without containment components.**	**Effective in the long-term with proper maintenance of containment components.** Containment components provide long-term performance. Barrier wall does not require routine maintenance. **Potential site risks remain without containment components.**
Reduction of Toxicity, Mobility, or Volume	**Does not reduce toxicity, mobility, or volume.**	**Reduces mobility of contaminants** with respect to direct contact exposure (e.g., generation of dust and vapors) and groundwater migration. **Reduces volume of visible elemental mercury** through treatment of mercury vapor (approximately 57 pounds of elemental mercury vapor per year converted to mercuric sulfide). **Contamination will remain onsite. Risk managed through containment components.**	**Reduces mobility of contaminants** with respect to direct contact exposure (e.g., generation of dust and vapor) and groundwater migration. **Reduces volume of visible elemental mercury** through treatment of mercury vapor (approximately 57 pounds of elemental mercury vapor per year converted to mercuric sulfide). **Contamination will remain onsite. Risk managed through containment components.**	**Reduces mobility of contaminants** with respect to direct contact exposure (e.g., generation of dust and vapor) and groundwater migration. **Reduces volume and mobility of visible elemental mercury** through in-situ treatment (lower solubility, no vapor pathway). Estimated 58% of visible elemental mercury in soil would be converted to mercuric sulfide. **Potential to increase mobility of other constituents** (e.g., arsenic) **Irreversibility of treatment uncertain.** **Contamination will remain onsite. Risk managed through containment components.**	**Reduces mobility of contaminants** with respect to direct contact exposure (e.g., generation of dust and vapor) and groundwater migration. **Reduces volume and mobility of visible elemental mercury** through in-situ treatment (lower solubility, no vapor pathway). Estimated 75% of visible elemental mercury in soil would be converted to mercuric sulfide. **Potential to increase mobility of other constituents** (e.g., arsenic) **Irreversibility of treatment uncertain.** **Contamination will remain onsite. Risk managed through containment components.**	**Reduces mobility of contaminants** with respect to direct contact exposure (e.g., generation of dust and vapor) and groundwater migration. **Reduces volume of visible elemental mercury** through excavation and off-site disposal. Estimated 77% of visible elemental mercury in soil would be removed and disposed off-site. **Removal of soils containing visible elemental mercury is permanent**. **Contamination will remain onsite. Risk managed through containment components.**	**Reduces mobility of contaminants** with respect to direct contact exposure (e.g., generation of dust and vapor) and groundwater migration. **Reduces volume of visible elemental mercury** through excavation and off-site disposal. Estimated 100% of visible elemental mercury in soil would be removed and disposed off-site. **Removal of soils containing visible elemental mercury is permanent**. **Contamination will remain onsite. Risk managed through containment components.**

Table ES-2. Detailed Evaluation of Site Remedies, Page 3 of 4
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Evaluation Criteria	**Site Remedy No. 1** No Action	**Site Remedy No. 2** Partial Containment (Treatment Cap)	**Site Remedy No. 3** Full Containment (Treatment Cap and Barrier Wall)	**Site Remedy No. 4a** Full Containment and Partial Depth Selective Stabilization	**Site Remedy No. 4b** Full Containment and Full Depth Selective Stabilization	**Site Remedy No. 5a** Full Containment and Partial Depth Selective Excavation and Off-Site Disposal	**Site Remedy No. 5b** Full Containment and Full Depth Selective Excavation and Off-Site Disposal
Short-Term Effectiveness	**No short-term impacts because no action taken.**	**Typical construction related impacts** (e.g., noise, dust, traffic). **Potential for small increase in mercury soil vapor generation** due to construction activities (~7.7 pounds during implementation). **Minimal risk to workers and community during implementation.** **Time period to obtain RAOs: 1 – 2 years** (except for groundwater standards)	**Typical construction related impacts** (e.g., noise, dust, traffic). **Potential for small increase in mercury soil vapor generation** due to construction activities (~7.7 pounds during implementation). **Minimal risk to workers and community during implementation.** **Time period to obtain RAOs: 1 – 2 years** (except for groundwater standards)	**Typical construction related impacts** (e.g., noise, dust, traffic). **Limited increase in mercury soil vapor generation** due to construction activities. (~0.5 pounds during implementation) **Potential risk to workers during handling of stabilization chemicals** **Minimal risk to community during implementation.** **Time period to obtain RAOs: 3– 4 years** (except for groundwater standards)	**Typical construction related impacts** (e.g., noise, dust, traffic). **Limited increase in mercury soil vapor generation** due to construction activities. (~0.8 pounds during implementation) **Potential risk to workers during handling of stabilization chemicals.** **Minimal risk to community during implementation.** **Time period to obtain RAOs: 3– 4 years** (except for groundwater standards)	**Typical construction related impacts** (e.g., noise, dust, traffic). **Potential for large increase in mercury soil vapor generation** due to construction activities (~101 pounds during implementation). **Increased risk to workers** due to increase in mercury vapor generation. **Increased risk to community** due to increased mercury soil vapor generation and transportation of visible elemental mercury contaminated soils and other materials through residential areas. **Time period to obtain RAOs: 1 – 2 years** (except for groundwater standards).	**Typical construction related impacts** (e.g., noise, dust, traffic). **Potential for large increase in mercury soil vapor generation** due to construction activities (~197 pounds during implementation). **Increased risk to workers** due to increase in mercury vapor generation. **Increased risk to community** due to increased mercury soil vapor generation and transportation of visible elemental mercury contaminated soils and other materials through residential areas. **Time period to obtain RAOs: 1 – 2 years** (except for groundwater standards)

Table ES-2. Detailed Evaluation of Site Remedies, Page 4 of 4
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Evaluation Criteria	**Site Remedy No. 1** No Action	**Site Remedy No. 2** Partial Containment (Treatment Cap)	**Site Remedy No. 3** Full Containment (Treatment Cap and Barrier Wall)	**Site Remedy No. 4a** Full Containment and Partial Depth Selective Stabilization	**Site Remedy No. 4b** Full Containment and Full Depth Selective Stabilization	**Site Remedy No. 5a** Full Containment and Partial Depth Selective Excavation and Off-Site Disposal	**Site Remedy No. 5b** Full Containment and Full Depth Selective Excavation and Off-Site Disposal
Implementability	**Implementable.**	**Implementable.** Implementable with conventional materials and equipment.	**Implementable.** Implementable with conventional materials and equipment.	**Implementable.** Implementable with conventional materials and equipment. Specialized equipment for soil mixing process, but generally available. **Treatability and pilot studies required.** **Subsurface obstructions may impede or slow implementation**, but shallow depth of treatment aids in addressing obstructions.	**Implementable.** Implementable with conventional materials and equipment. Specialized equipment for soil mixing process, but generally available. **Treatability and pilot studies required.** **Subsurface obstructions likely to impede or slow implementation** (more difficult compared to Combined Site Remedy No. 4a due to increased depth of treatment).	**Implementable.** Implementable with conventional materials and equipment. **Potential increase in worker protection required** (i.e., PPE) due to increase in mercury soil vapor generation. **Disposal of soil outside US potentially required**, limits options for management of excavated material. Less stringent regulatory requirements for management of mercury waste outside US. **Disposal facility may have limitations on acceptance** and has never processed mercury contaminated soils at this scale **Treatability and process implementability study required** (to be performed by disposal facility) **Subsurface obstructions may impede or slow implementation**, but shallow depth of excavation aids in addressing obstructions.	**Implementable.** Implementable with conventional materials and equipment. **Potential increase in worker protection required** (i.e., PPE) due to increase in mercury soil vapor generation. **Disposal of soil outside US potentially required,** limits options for management of excavated material. Less stringent regulatory requirements for management of mercury waste outside US. **Disposal facility may have limitations on acceptance** and has never processed mercury contaminated soils at this scale. **Treatability and process implementability study required** (to be performed by disposal facility) **Subsurface obstructions likely to impede or slow implementation** (more difficult compared to Combined Site Remedy No. 5a due to increased depth of soil removal, and subsurface obstructions).
Cost **(NPW, 30 years, 5% discount rate)**	None	$20,960,000	$24,861,000	$29,585,000 to $38,594,000 (dependent on sulfur loading for soil stabilization process)	$30,501,000 to $42,084,000 (dependent on sulfur loading for soil stabilization process)	$74,760,000 to $95,982,000 (dependent on potential for retorting soil following Stablex process)	$84,332,000 to $109,658,000 (dependent on potential for retorting soil following Stablex process)

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Table ES-3. Comparative Analysis of Site Remedies, Page 1 of 3
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Evaluation Criteria	Site Remedy No. 1 No Action	Site Remedy No. 2 Partial Containment (Treatment Cap)	Site Remedy No. 3 Full Containment (Treatment Cap and Barrier Wall)	Site Remedy No. 4a Full Containment and Partial Depth Selective Stabilization	Site Remedy No. 4b Full Containment and Full Depth Selective Stabilization	Site Remedy No. 5a Full Containment and Partial Depth Selective Excavation and Off-Site Disposal	Site Remedy No. 5b Full Containment and Full Depth Selective Excavation and Off-Site Disposal
Protection of Human Health and the Environment	Not protective of human health or the environment Relative Scale = 1	Protective of human health and the environment Relative Scale = 8	Protective of human health and the environment Relative Scale = 10	Protective of human health and the environment Relative Scale = 10	Protective of human health and the environment Relative Scale = 10	Protective of human health and the environment Relative Scale = 10	Protective of human health and the environment Relative Scale = 10
Compliance w/ ARARs	Does not comply the ARARs Relative Scale = 1	Complies with ARARs Relative Scale = 10	Complies with ARARs Relative Scale = 10	Complies with ARARs Relative Scale = 10	Complies with ARARs Relative Scale = 10	In general complies with ARARs (less stringent requirements outside US) Relative Scale = 8	In general complies with ARARs (less stringent requirements outside US) Relative Scale = 8
Long-Term Effectiveness	No long-term effectiveness Relative Scale = 1	Effective in long-term with proper maintenance. Relative Scale = 8	Effective in long-term with proper maintenance. Relative Scale = 8	Effective in long-term with proper maintenance. Permanence of conversion of elemental Hg to HgS uncertain. Relative Scale = 8	Effective in long-term with proper maintenance. Permanence of conversion of elemental Hg to HgS uncertain. Relative Scale = 8	Effective in long-term with proper maintenance. Removal of soil containing visible elemental Hg is permanent. Relative Scale = 8	Effective in long-term with proper maintenance. Removal of soil containing visible elemental Hg is permanent. Relative Scale = 8

Deleted: potential circumvention of LDRs or ATSs

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Table ES-3. Comparative Analysis of Site Remedies, Page 2 of 3
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Evaluation Criteria	**Site Remedy No. 1** No Action	**Site Remedy No. 2** Partial Containment (Treatment Cap)	**Site Remedy No. 3** Full Containment (Treatment Cap and Barrier Wall)	**Site Remedy No. 4a** Full Containment and Partial Depth Selective Stabilization	**Site Remedy No. 4b** Full Containment and Full Depth Selective Stabilization	**Site Remedy No. 5a** Full Containment and Partial Depth Selective Excavation and Off-Site Disposal	**Site Remedy No. 5b** Full Containment and Full Depth Selective Excavation and Off-Site Disposal
Reduction of Toxicity, Mobility, or Volume	Does not reduce toxicity, mobility, or volume Relative Scale = 1	Reduces mobility through containment and potentially toxicity/volume through Hg vapor treatment Relative Scale = 4	Reduces mobility through containment and potentially toxicity/volume reduction through Hg vapor treatment Relative Scale = 4	Reduces mobility through containment and converts elemental Hg to HgS which is less soluble and does not emit vapor. 58% Hg soil treated Relative Scale = 6	Reduces mobility through containment and converts elemental Hg to HgS which is less soluble and does not emit vapor. 75% Hg soil treated Relative Scale = 7	Reduces mobility through containment and volume reduction through excavation and off-site disposal. 77% Hg soil removed Relative Scale = 8	Reduces mobility through containment and volume reduction through excavation and off-site disposal. 100% Hg soil removed Relative Scale = 10
Short-Term Effectiveness	No short term impacts, no implementation items Relative Scale = 1	Potential for increase in Hg vapor generation during construction. Minimal risk to workers and community Implementation time 1-2 years. Relative Scale = 8	Potential for increase in Hg vapor generation during construction. Minimal risk to workers and community Implementation time 1-2 years. Relative Scale = 8	Limited potential for increase in Hg vapor generation during construction. Minimal risk to community. Potential risk to workers handling stabilization chemicals Implementation time 3-4 years. Relative Scale = 6	Limited potential for increase in Hg vapor generation during construction. Minimal risk to community. Potential risk to workers handling stabilization chemicals Implementation time 3-4 years. Relative Scale = 5	Elevated potential for increase in Hg vapor generation during construction activities. Increased risk to workers and community due to Hg vapor generation and transportation of elemental Hg. Implementation time 1-2 years. Relative Scale = 4	Elevated potential for increase in Hg vapor generation during construction activities. Increased risk to workers and community due to Hg vapor generation and transportation of elemental Hg. Implementation time 1-2 years. Relative Scale = 3

Table ES-3. Comparative Analysis of Site Remedies, Page 3 of 3
LCP Chemicals, Inc. Superfund Site
Feasibility Study

Evaluation Criteria	**Site Remedy No. 1** No Action	**Site Remedy No. 2** Partial Containment (Treatment Cap)	**Site Remedy No. 3** Full Containment (Treatment Cap and Barrier Wall)	**Site Remedy No. 4a** Full Containment and Partial Depth Selective Stabilization	**Site Remedy No. 4b** Full Containment and Full Depth Selective Stabilization	**Site Remedy No. 5a** Full Containment and Partial Depth Selective Excavation and Off-Site Disposal	**Site Remedy No. 5b** Full Containment and Full Depth Selective Excavation and Off-Site Disposal
Implementability	Readily implemented. Relative Scale = 10	Implementable with conventional materials and equipment. Relative Scale = 8	Implementable with conventional materials and equipment. Relative Scale = 8	Implementable with conventional materials and equipment, plus specialized equipment for soil mixing. Treatability and pilot testing required Relative Scale = 6	Implementable with conventional materials and equipment, plus specialized equipment for soil mixing. Treatability and pilot testing required Relative Scale = 4	Implementable with conventional materials and equipment. Disposal of soil outside US required. Single disposal facility. Treatability/process implementability study required Relative Scale = 3	Implementable with conventional materials and equipment. Disposal of soil outside US required. Single disposal facility. Treatability/process implementability study required Relative Scale = 1
Cost **(NPW, 30 years, 7% discount rate)**	None Relative Scale = 10	\$20,960,000 Relative Scale = 9	\$24,861,000 Relative Scale = 8	\$29,585,000 to \$38,594,000 Relative Scale = 6	\$30,501,000 to \$42,084,000 Relative Scale = 5	\$74,760,000 to \$95,982,000 Relative Scale = 3	\$84,332,000 to \$109,658,000 Relative Scale = 1
Total Relative Scale[1]	25	55	56	52	49	44	41

Relative Scale: 1 ◄──────────► 10
Worse   Than Other Remedies   Better

Note:
[1] Total Relative Scale represents the sum of the individual criteria relative scale ratings. Remedies with higher Total Relative Scale meet requirements of the individual evaluation criteria better than remedies with lower Total Relative Scale (Maximum Total Relative Scale = 70, Minimum = 7)

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